BYTE

THE SMALL SYSTEMS JOURNAL

SEPTEMBER 1984 VOL. 9, NO. 10

$3.50 IN UNITED STATES
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A McGRAW-HILL PUBLICATION
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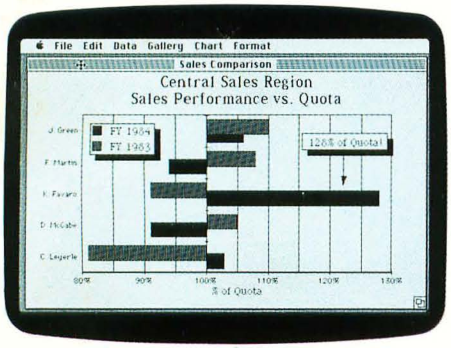
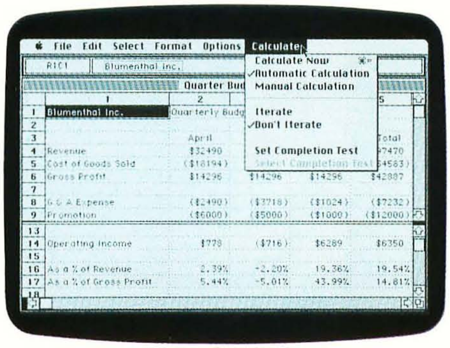
COMPUTER GRAPHICS

We interrupt this magazine fo

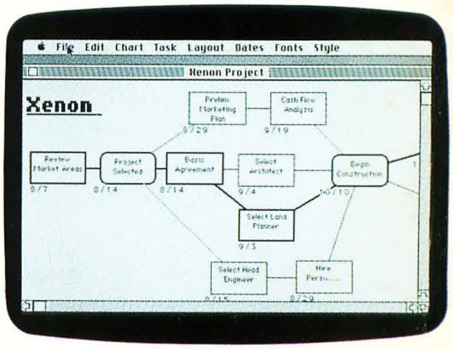


Microsoft Chart,
business graphics.

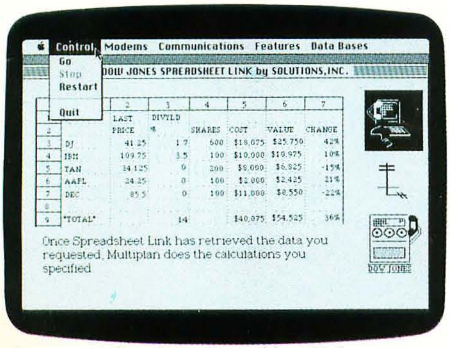


	1	2	3	4	5
1	Blumenthal Inc.	Quarterly Budg			
2					
3		April			Total
4	Revenue	$32490			97470
5	Cost of Goods Sold	($18194)			54583)
6	Gross Profit	$14296	$14296	$14296	$42887
7					
8	G & A Expense	($2490)	($3718)	($1024)	($7232)
9	Promotion	($6000)	($5000)	($1000)	($12000)
13					
14	Operating Income	$778	($716)	$6289	$6350
15					
16	As a % of Revenue	2.39%	-2.20%	19.36%	19.54%
17	As a % of Gross Profit	5.44%	-5.01%	43.99%	14.81%
18					

Microsoft Multiplan,
electronic spreadsheet.



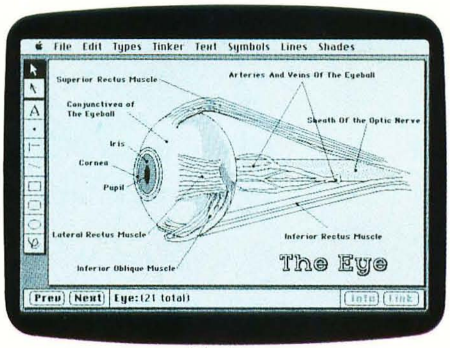
MacProject,
project management.



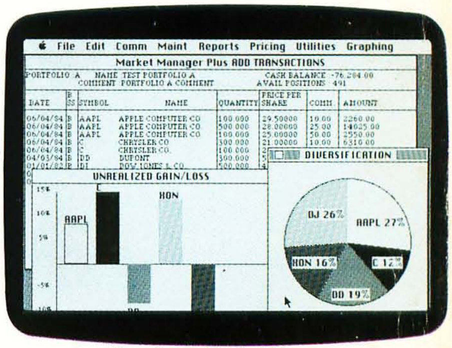
	1	2	3	4	5	6	7
1		LAST	DIVYLD				
2		PRICE	%	SHARES	COST	VALUE	CHANGE
3	DJ	41.25	1.7	600	$18,075	$25,750	42%
4	IBM	109.75	3.5	100	$10,000	$10,975	10%
5	TAN	34.125	0	200	$8,000	$6,825	-15%
6	AAPL	24.25	0	100	$2,000	$2,425	21%
7	DEC	85.5	0	100	$11,000	$8,550	-22%
8							
9	*TOTAL*		14		$40,075	$54,525	36%

Once Spreadsheet Link has retrieved the data you requested, Multiplan does the calculations you specified.

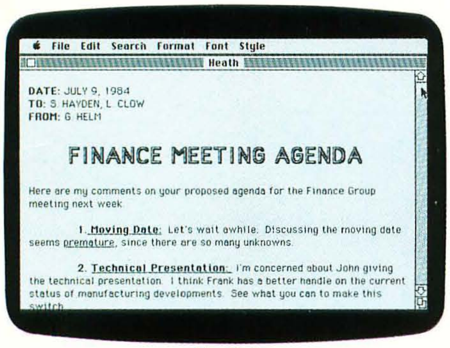
Dow Jones Spreadsheet Link,
stock analysis and communications.



Filevision,
database management.



Dow Jones Market Manager,
*stock analysis.**



DATE: JULY 9, 1984
TO: S. HAYDEN, L. CLOW
FROM: G. HELM

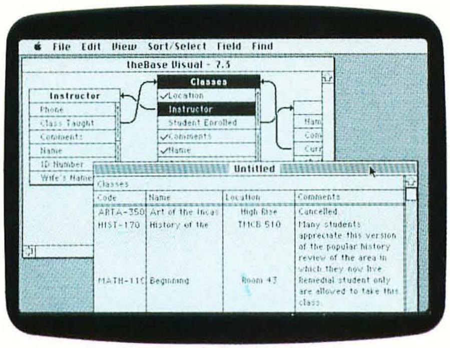
FINANCE MEETING AGENDA

Here are my comments on your proposed agenda for the Finance Group meeting next week.

1. Moving Date: Let's wait awhile. Discussing the moving date seems premature, since there are so many unknowns.

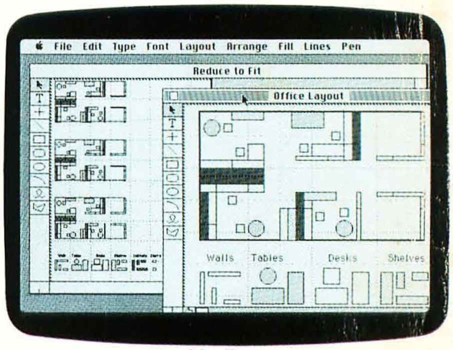
2. Technical Presentation: I'm concerned about John giving the technical presentation. I think Frank has a better handle on the current status of manufacturing developments. See what you can to make this switch.

MacWrite,
word processing.

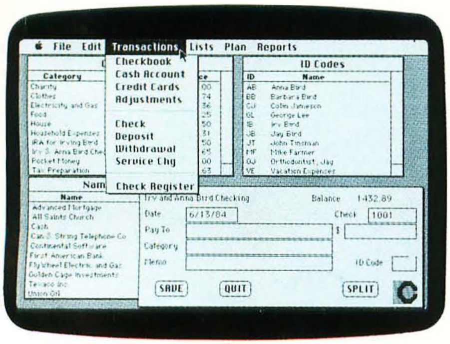


Code	Name	Location	Comments
ARTA-350	Art of the Incas	High Rise	Cancelled.
HIST-170	History of the	TMCB 510	Many students appreciate this version of the popular history review of the area in which they now live.
MATH-115	Beginning	Room 43	Remedial student only are allowed to take this class.

theBase,
database management.

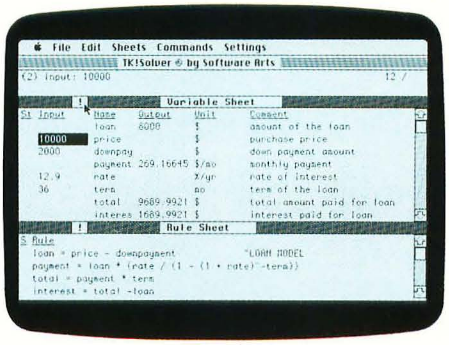


MacDraw,
graphic illustration.



Irv and Anna Bird Checking   Balance 1432.89
Date 6/13/84   Check 1001
Pay To
Category
Memo   ID Code

Home "Mac" Accountant,
personal finance.

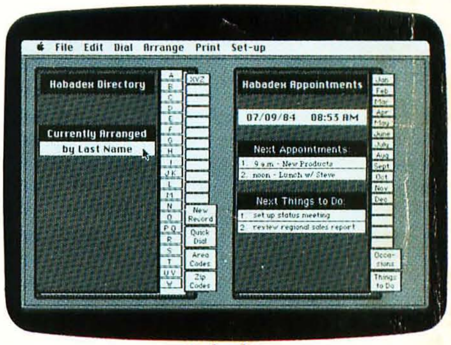


(2) Input: 10000   12 /

St	Input	Name	Output	Unit	Comment
		loan	8000	$	amount of the loan
	10000	price		$	purchase price
	2000	downpay		$	down payment amount
		payment	269.16645	$/mo	monthly payment
	12.9	rate		%/yr	rate of interest
	36	term		mo	term of the loan
		total	9689.9921	$	total amount paid for loan
		interes	1689.9921	$	interest paid for loan

```
S Rule
 loan = price - downpayment              "LOAN MODEL
 payment = loan * (rate / (1 - (1 + rate)^-term))
 total = payment * term
 interest = total -loan
```

TK! Solver,
equation processor.



07/09/84   08:53 AM

Next Appointments:
1. 9 a.m. - New Products
2. noon - Lunch w/ Steve

Next Things to Do:
1. set up status meeting
2. review regional sales report

Habadex,
database and communications.

*The programs above are just a few examples of new software for Macintosh. Some are available now, others will be released in the coming weeks. *Available 4th quarter, 1984. **Available 1st quarter, 1985. © 1984 Apple Computer Inc. Apple, the Apple logo, MacDraw, MacProject, MacTerminal, and MacWrite, are trademarks of Apple Computer Inc. Macintosh is a trademark licensed to Apple Computer Inc. For an authorized Apple dealer nearest you call* **(800) 538-9696.** *In Canada, call* **(800) 268-7796** *or* **(800) 268-7637.**

r some important programs.

Every business day, a new software program is being developed for the Macintosh™ Personal Computer.

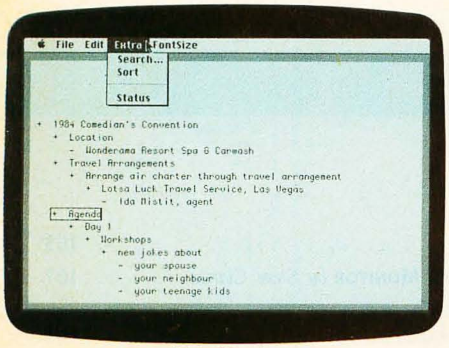
Software for word processing. Spreadsheets. Business graphics. Project management. Database management. And data communications.

As well as software that enables Macintosh to do things that have never been done on a computer before.

Which means the world's easiest-to-use business computer is well on its way to becoming the world's most useful business computer.

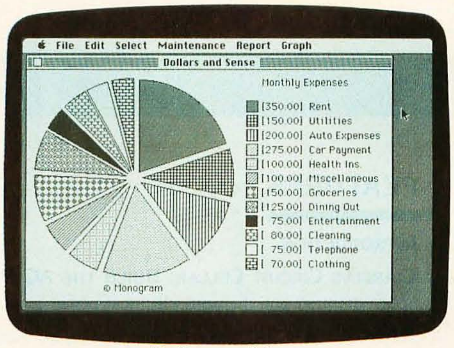
Any authorized Apple dealer will gladly demonstrate that fact.

Just ask to see the computer that's software compatible. With human beings.



- 1984 Comedian's Convention
  - Location
    - Wonderama Resort Spa & Carwash
  - Travel Arrangements
    - Arrange air charter through travel arrangement
      - Lotsa Luck Travel Service, Las Vegas
        - Ida Mistit, agent
  - Agenda
    - Day 1
      - Workshops
        - new jokes about
          - your spouse
          - your neighbour
          - your teenage kids

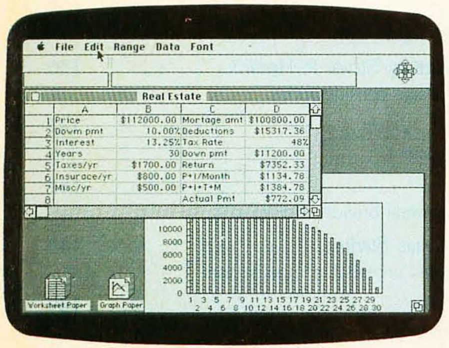
ThinkTank, idea processor.



Monthly Expenses

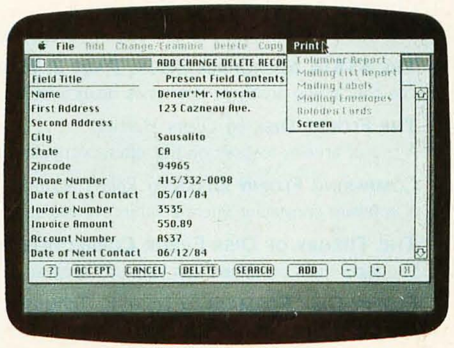
[350.00]	Rent
[150.00]	Utilities
[200.00]	Auto Expenses
[275.00]	Car Payment
[100.00]	Health Ins.
[100.00]	Miscellaneous
[150.00]	Groceries
[125.00]	Dining Out
[75.00]	Entertainment
[80.00]	Cleaning
[75.00]	Telephone
[70.00]	Clothing

Dollars and $ense, personal finance.



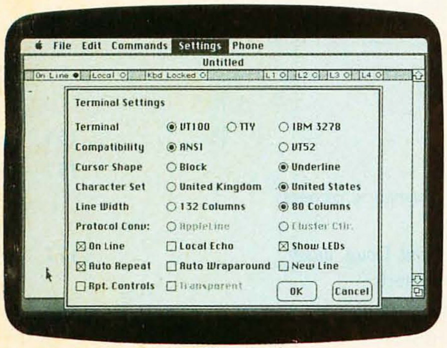
	A	B	C	D
1	Price	$112000.00	Mortage amt	$100800.00
2	Dowm pmt	10.00%	Deductions	$15317.36
3	Interest	13.25%	Tax Rate	48%
4	Years	30	Down pmt	$11200.00
5	Taxes/yr	$1700.00	Return	$7352.33
6	Insurace/yr	$800.00	P+I/Month	$1134.78
7	Misc/yr	$500.00	P+I+T+M	$1384.78
8			Actual Pmt	$772.09

*The Lotus Macintosh Product, integrated business software.***



Field Title	Present Field Contents
Name	Deneu*Mr. Moscha
First Address	123 Cazneau Ave.
Second Address	
City	Sausalito
State	CA
Zipcode	94965
Phone Number	415/332-0098
Date of Last Contact	05/01/84
Invoice Number	3535
Invoice Amount	550.89
Account Number	AS37
Date of Next Contact	06/12/84

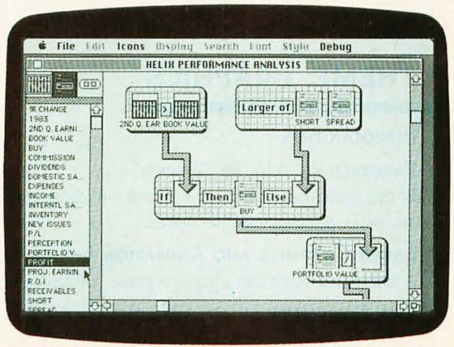
Main Street Filer, database management.



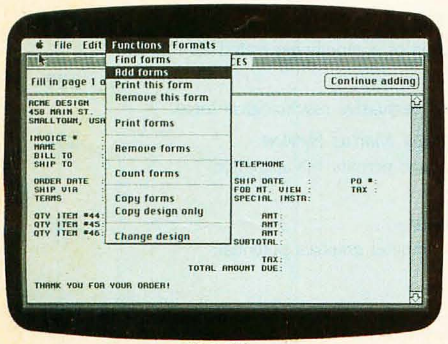
Terminal Settings

Terminal ● VT100 ○ TTY ○ IBM 3278
Compatibility ● ANSI ○ VT52
Cursor Shape ○ Block ● Underline
Character Set ○ United Kingdom ● United States
Line Width ○ 132 Columns ● 80 Columns
Protocol Conv: ○ AppleLine ○ Cluster Ctlr.
☒ On Line ☐ Local Echo ☒ Show LEDs
☒ Auto Repeat ☐ Auto Wraparound ☐ New Line
☐ Rpt. Controls ☐ Transparent

MacTerminal, data communications.



Helix, relational database.



Fill in page 1 o

ACME DESIGN
458 MAIN ST.
SMALLTOWN, USA

INVOICE # :
NAME :
BILL TO :
SHIP TO : TELEPHONE :

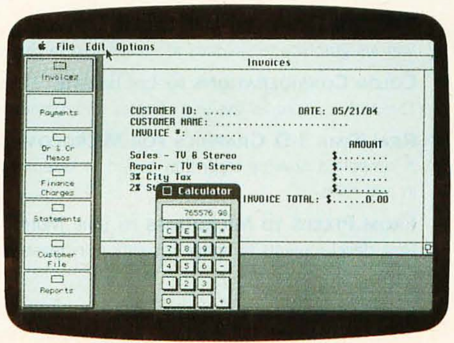
ORDER DATE : SHIP DATE : PO #:
SHIP VIA : FOB MT. VIEW : TAX :
TERMS : SPECIAL INSTR:

QTY ITEM #44: AMT:
QTY ITEM #45: AMT:
QTY ITEM #46: AMT:
SUBTOTAL:

TAX:
TOTAL AMOUNT DUE:

THANK YOU FOR YOUR ORDER!

PFS: File, database management.

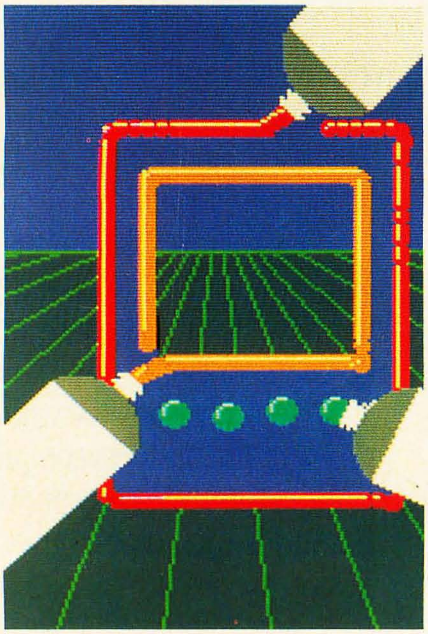


CUSTOMER ID: ...... DATE: 05/21/84
CUSTOMER NAME: ....
INVOICE #: ....

	AMOUNT
Sales - TV & Stereo	$.........
Repair - TV & Stereo	$.........
3% City Tax	$.........
2% St	$.........
INVOICE TOTAL:	$......0.00

Peachtree's Back to Basics, accounting package.

C·O·N·T·E·N·T·S



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Your computer can measure electrical power consumption.

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COVER ILLUSTRATION:
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Barbara Nessim created this month's cover and section artwork with a Norpak videotex (NAPLPS) system. This PDP-11/03-based workstation runs Information Provider System (IPS-2) software, providing 6 drawing modes (arc, rectangle, circle, line, dot, and polygon) and 12 colors plus black and white.

SECTION ART:
Computer Design Direction: Barbara Nessim
Illustration: Liz Gutowski
In Time Design Studio

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68000-based systems. Just tell us what you need.

68000-based systems to fit your application.

Right from the pages of our catalog, we can deliver 68000-based supermicro systems to match virtually any application.

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Here's how.

Built on the IEEE-696 (S-100) bus, Cromemco systems offer up to 21 board slots. And a family of 35 boards — CPU, memory and specialized I/O — to fill the slots any way you choose.

At the heart of each system is our 68000/Z-80 dual processor. Backed by as much as 16 Mb of error-correcting RAM. Full multi-tasking capability. I/O to handle up to 16 terminals.

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You can select single or dual floppies, 5¼" or 8." A 50 Mb 5¼" Winchester hard disk. And a nine-track tape drive.

We can accommodate your taste for the exotic, too. With boards like our SMD interface that supports up to 1200 Mb of disk storage. A fast floating-point processor. A color graphics interface. A TV camera digitizer. An IEEE-488 bus interface. Communications. And more.

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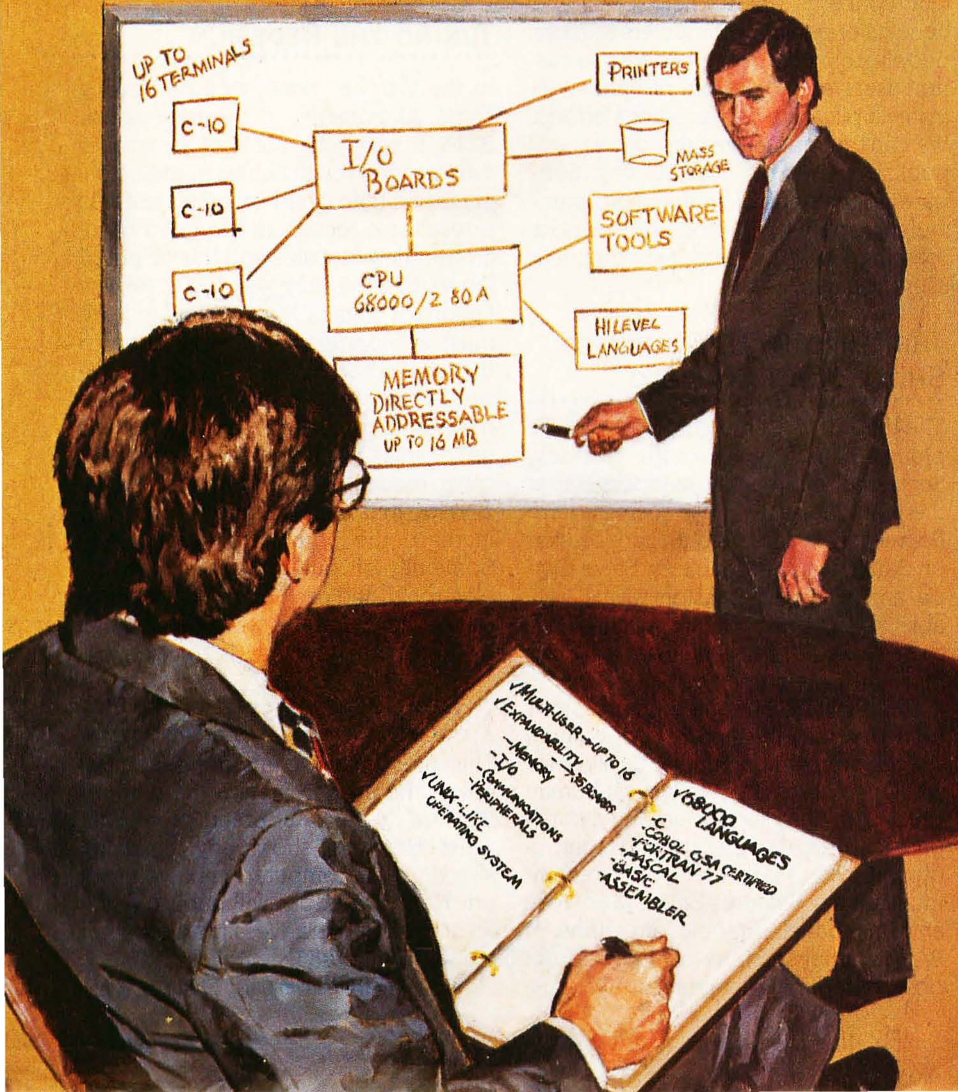
Then, if you're designing a distributed processing system, you'll want to take a look at our C-10 personal computer. The Z-80-based C-10 can serve our 68000-based systems as a powerful intelligent workstation in a distributed processing mode. Or as an independent personal computer with its own floppy storage.



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That brings us to software. It starts with CROMIX,® our UNIX™-like operating system that you're free to tailor to your application.

CROMIX can execute both 68000- and Z-80-based programs. So right along with your 68000-based packages, your system will accommodate a wide selection of CP/M® software written for the Z-80.

And our high-level language support is second to none. From a 68000 Macro Assembler. To 68000 FORTRAN 77, PASCAL, GSA-certified high-level COBOL, C and BASIC.

Cromemco means business. Your business.

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E·D·I·T·O·R·I·A·L

MISSING SOFTWARE

Almost all of us these days have wish lists of software we know we'll never write ourselves. This applies to sophisticated personal computer users as well as to those who do little programming. In brief, the problem is that we can dream up more software than we have time to code. Few people can interrupt work for six months or a year to write a complex program—even if the program would increase personal efficiency by 20 percent or more.

On the other hand, there are many talented programmers eyeing the flourishing software market who don't know what to write. It's clear that the world doesn't need yet another word processor or spreadsheet for the IBM Personal Computer, but much less clear what the world does need. The mass of personal computer users consists of many segments. There are engineers and scientists in various specialties, managers and administrators in many different industries, academics in all the arts and sciences, students and teachers at all levels, and many others. Many of these different segments are big enough to constitute a significant market for software. But there is no convenient way for these markets to communicate their needs to programmers.

People often call BYTE to ask if anyone here knows of software to perform some particular task or to serve some specialty. An anthropologist may ask about software for analyzing transcribed oral histories. A physician may seek software that converts diagnostic notes into the standard form required by federal health insurance. Occasionally we can help, but more often we are frustrated because we can't make a recommendation or a referral.

BYTE now proposes to provide a means of communication between people in need of software and the thousands of programmers who read BYTE. If you need software, write "Missing Software," c/o BYTE, POB 372, Hancock, NH 03449. Be sure to include the following information:

1. Exactly what must the software do?
2. Where can the programmer get detailed information necessary to write the software?
3. How many people do you estimate need the software, and what is the basis of the estimate?
4. What would potential users be willing to pay for a license to the software?
5. How could a programmer best market the completed program to the people who need it?

Please note that BYTE has no intention of entering the software business. Our concerns are to help bring the benefits of personal computers to more people, to increase the benefits to current users, and to prevent programmers from duplicating one another's efforts. We can't guarantee results, but we will publish responses to "Missing Software" in the hope of enabling programmers to apply their efforts to the most pressing needs of personal computer users today.

THE THIRD BYTE COMPUTER SHOW: SAN FRANCISCO

The third BYTE Computer Show will take place Thursday through Sunday, September 6 through 9, in Brooks Hall at the San Francisco Civic Center. Jerry Pournelle will address a plenary session on Saturday afternoon. Jerry, Steve Ciarcia, and several BYTE editors will be available in our booth during much of the show. Cover artist Robert Tinney will bring reproductions of many BYTE covers.

There will be 25 conference sessions held Thursday through Saturday, and a special program on Sunday. Conference sessions will include: West Coast Bureau Chief Ezra Shapiro moderating a panel on idea-processing software; Contributing Editor Mark Klein on telecommunications; Features Editor Mike Vose and his panel on new directions in BASIC. Other sessions include: a forum on programming languages; a discussion of next-generation operating systems; a program on robotics; and others on artificial intelligence, the C language, graphics add-ons, notebook computers, databases, and many other topics.

This is not an industry show, but one for computer users. Many exhibitors will be selling equipment and software, so you'll have a chance to enhance your system and increase your knowledge of personal computing. The second BYTE Computer Show, held in June in Los Angeles, had good attendance, strong conference sessions, lively discussions, and some real bargains. We have great hopes for the San Francisco show and plan to see you there.

TUNING THE REDESIGN

In the October issue, we'll be making some adjustments in the redesign of BYTE. In particular, some of the smaller type printed much lighter in the actual magazine than it had in limited tests. As a result, we recognize the need to increase the point size and the weight of letters to the editor, Ask BYTE, Review Feedback, Chaos Manor Mail, etc. We must apologize for the small type to those who had difficulty reading it. We were just trying to pack in more information. To those who applauded the use of small type to get more letters and other reader feedback into the magazine, we must apologize for the need to increase the point size next month. Some day, of course, magazines will be electronic, and each reader will be able to set the type face and point size as desired. Alas, that day is not yet.

COMPUTER ARTIST

This month, our computer-generated cover and section art are the work of Barbara Nessim, a noted New York artist. Her work shows any remaining skeptics that computers mix well with art. Harmony Books will publish a collection of Barbara Nessim's computer art in Spring 1985.

—*Phil Lemmons, Editor in Chief*

What if your PC suddenly became faster, smarter and easier to use?

You're going to be hearing a lot about our new productivity software, Framework.™ You'll see business magazine ads and even TV commercials. But those aren't for you. They're directed at the first time PC buyers.

Right here is where you'll get the inside story on Framework.

Framework introduces a new generation of software. It's the logical step beyond spreadsheet-based integrated software like 1-2-3.™

Framework is for thinkers. It's an idea processor that's equally comfortable with words and numbers. Novices can learn Framework's unique outlining feature, word processing, spreadsheet, graphics, and database in a matter of hours. But what's really in Framework for you?

You can run PC DOS compatible programs like dBASE II® or 1-2-3 within Framework. You can write macros easier and faster than ever.

Framework has a full applications language named Fred,™ which is going to make it the hottest ticket for third-party developers since dBASE II.

And you can ignore all of Framework's friendly menus and HELP features for beginners, because Framework works even better and faster with power commands.

The more you know about software, the more amazed you're going to be when you see Framework.

For more information call
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or in Colorado (303) 799-4900
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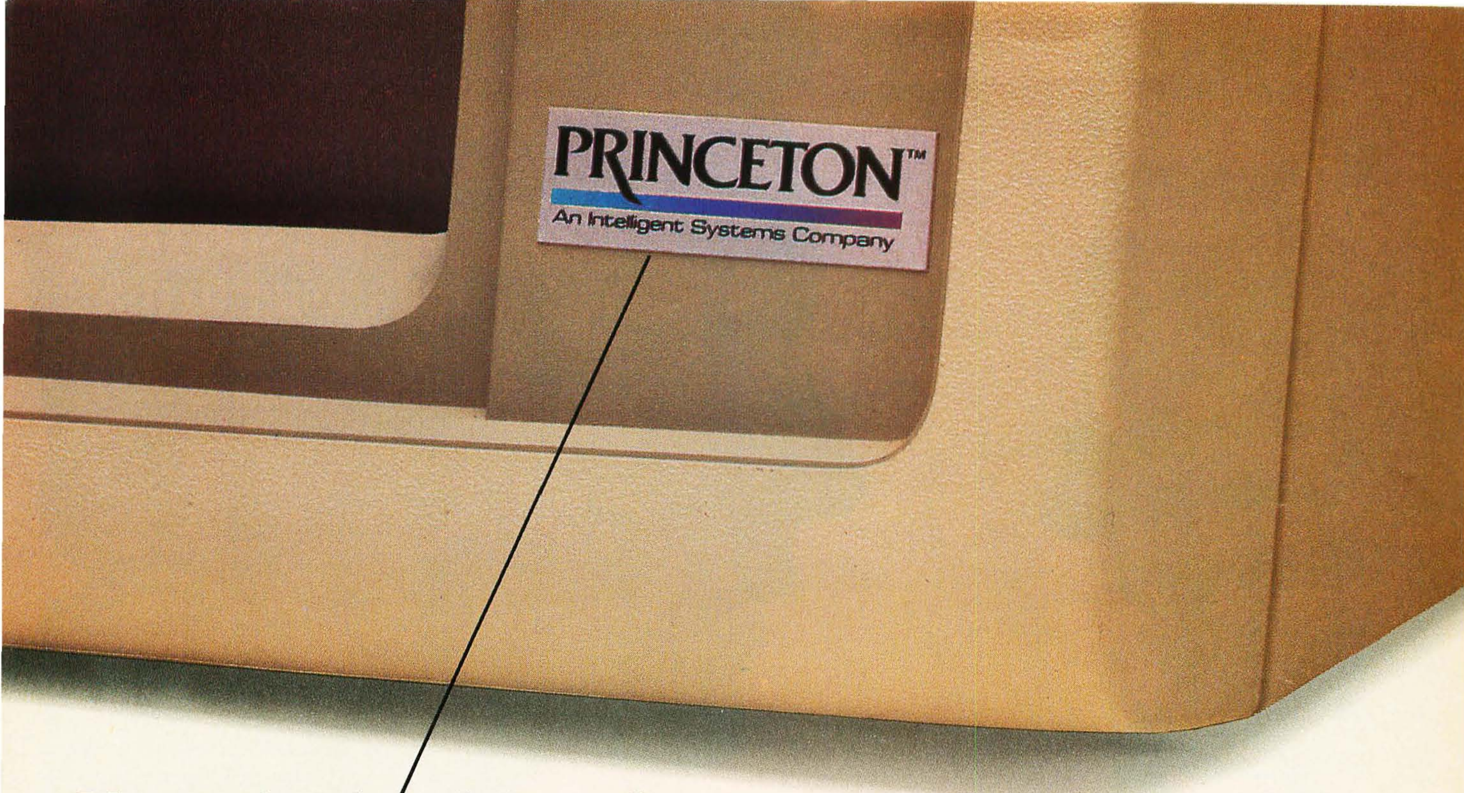


If you're looking for a quality monitor, look for this symbol.

HX-12. A high resolution monitor at a medium resolution price.

HX-12 is a high resolution RGB color monitor that's colorful enough for all your graphics needs and sharp enough for word processing.

With its own cable that plugs directly into the IBM PC, the HX-12 delivers a rainbow of 16 colors on a non-glare screen. All that includes clean whites without red bleed. In fact, all the colors are clean and crisp thanks to the HX-12's .31mm dot pitch and 690 × 240 (non-interlaced) resolution.

Shop around. Nothing else compares to the HX-12 priced at just **$695.**

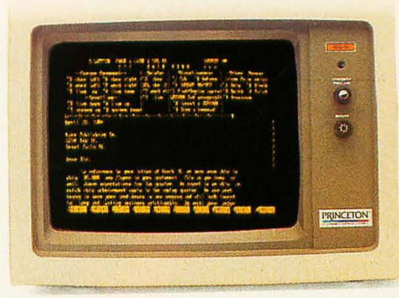
The SR-12 delivers even better resolution color for a better-than-ever price.

At first glance, the SR-12 might appear similar to the HX-12 with a non-glare screen and .31mm dot pitch supporting 690 horizontal resolution. But take a closer look. SR-12's scan frequency is 31.5 KHz, allowing the SR-12 to support 480 vertical resolution in non-interlaced mode. That means a high-quality, flickerless image with text that's up to monochrome standards. What's more, you get all that quality for **$799.**

For full compatibility with all IBM software, get the **Princeton Scan Doubler**. Priced at **$249,** it allows you to run the SR-12 from a standard IBM or IBM equivalent color card in the IBM PC.

You can't beat the SR-12 for resolution or price.

MAX-12. You won't find a better monochrome monitor for a better price.



PGS combines easy-on-the-eyes amber phosphor and exceptional 800 × 350 resolution to give you the MAX-12, the best monochrome monitor for your money.

Check the non-glare screen. Dynamic focusing circuitry keeps the image sharp, not only in the center, but around the edges and in the corners. Then check the price. At **$249** the MAX-12 is less expensive than the leading green-on-black competitor. And there's more. The MAX-12 works with the IBM PC and other IBM compatibles.

For clarity, performance and price, your choice is clear. Make it the new MAX-12.

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MICROBYTES

Staff-written highlights of late developments in the microcomputer industry.

Macintosh Products Get Attention at NCC

A number of products for Apple's Macintosh were shown at the National Computer Conference in July, although most of them won't be available until late fall.

Thunderware Inc., Orinda, CA, showed a unique $200 image digitizer for the Macintosh. The device is attached to the print head of the Imagewriter printer, scanning any page fed through the printer with a resolution of 200 dots per inch in 256 levels of gray. The device should be available later this month.

Koala Technologies showed MacVision, which allows video cameras or videocassette recorders to interface with the Macintosh. The resulting bit-mapped images can be modified using MacPaint. MacVision will be available for about $300 in late fall. A similar product, Micron Technology's MicronEye Bullet, is now available for $395, including the camera unit.

Intermatrix Corp., North Hollywood, CA, announced MacPhone. This $200 system includes a telephone and software to automatically dial numbers and log calls. A later product may add telecommunications features.

Sunol Systems, Pleasanton, CA, announced Sun*Mac, a network system. As many as 32 Macintoshes can be linked to the $700 Sun*Mac, which must be connected to a $400 Sun*Net unit, to which up to three other computers or additional Sun*Nets can also be attached. Sun*Net is linked in turn to Sunol's Sun*Disk hard-disk units.

Mark of the Unicorn, Cambridge, MA, announced Professional Composer, a $495 music-editing system. Softworks Limited, Chicago, IL, is selling a $395 C compiler. Epson demonstrated a $30 program that enables the Macintosh to use Epson's FX-80 printer.

Expertelligence Inc., Santa Barbara, CA, announced ExperLogo. This $149 version of Logo includes Bunny Graphics and is incrementally compiled. A version of LISP is planned.

Double-Gold Software, San Jose, CA, is selling Lock-It-Up, a disk copy-protection system for the Macintosh, in addition to versions for the Apple II and IBM PC. Double-Gold licenses the software for $495.

Macintosh-like Capabilities for IBM PC, Epson QX-10

While Apple scrambles to provide software for the Macintosh, several companies are trying to make other computers look like the Macintosh. Bellesoft, Bellevue, WA, has introduced a line of pop-up programs for the IBM PC. Using a common Pop-Up kernel, the programs can be accessed from any application program. PopDOS makes most DOS commands available within other applications. Alarm Clock and Calendar programs will cost $19.95; Note Pad, Calculator, and PopDOS are $39.95 each; and TeleComm will cost $79.95. Bellesoft plans to distribute free copies of Alarm Clock to promote the line.

International Microcomputer Software Inc., San Rafael, CA, announced PC Paintbrush, a color graphics program similar to Apple's MacPaint. PC Paintbrush for the IBM PC should be available this month for about $130. Rising Star Industries displayed ValPaint, also similar to MacPaint, for the Epson QX-10 computer. ValPaint will be available from Epson in the fall.

IBM announced PCjr ColorPaint, a cartridge-based drawing program due out this month. The $99 software includes many MacPaint-type features, with 640- by 200-pixel resolution in color. (The Macintosh displays 512 by 342 pixels.) ColorPaint requires a two-button mouse; IBM will not offer one but said the program will work with Mouse Systems' or Microsoft's mice.

Optical Disks Shown at NCC

Four companies displayed optical-disk-storage products for computers at this year's National Computer Conference and at the National Office Machine Dealers Association convention.

Panasonic showed its $27,000 digital Optical Memory Disk Recorder (OMDR), which uses an 8-inch optical disk with a capacity of 700 megabytes per side. Alcatel Thomson CSF displayed its 1-gigabyte Gigadisc optical-disk drive. The drive will cost $10,000 in quantity, and a controller will cost $3100. Shugart showed a similar drive. Hitachi showed its Optical Disk Subsystem, which can store 1.3 gigabytes on each side of a 12-inch optical disk. The Hitachi system will cost approximately $15,000 in very large quantities.

IBM Announces PCjr Enhancements, Software, Education Program

IBM replaced the PCjr's "Chiclet" keyboard with a typewriter-style keyboard, which will be standard on the PCjr and free for all current PCjr owners. IBM also announced $325 128K-byte memory-expansion units for the PCjr. To use more than one expansion unit, you must also buy a $150 power supply; with it, the PCjr can be expanded to 512K bytes. IBM also announced a national program called "Writing to Read," which teaches reading and writing using PCjrs and typewriters, and said it will offer discounts on PCjrs to all teachers and schools.

High-Resolution Printers Unveiled at NCC

Quality Micro Systems, Mobile, AL, introduced the QMS SmartWriter, a $4495 laser printer based on Canon's 8-page-per-minute print engine. Golden Dawn Computer Systems, Salt Lake City, UT, introduced the $3495 Golden Laser, also based on the Canon machine. Canon added the LBP-20, a 20-page-per-minute laser printer, while Fujitsu showed its own $16,000 16-page-per-minute unit. Ricoh showed a 12-page-per-minute laser printer that will be sold to other manufacturers for as little as $5000 without a controller. Both Fujitsu and Ricoh also showed image digitizers to complement the printers.

Canon also announced the F-60, a $545 thermal-transfer printer with a resolution of 360 dpi. Mitsubishi announced the $1100 M4234, a 180-dpi, seven-color, thermal-transfer printer. Mitsubishi also showed the CP-5, a $1200 392-dpi printer that produced near photograph quality color images but won't be available for at least a year.

NANOBYTES

Cromemco unveiled a new line of S-100 computers using UNIX System V. The 68000-based System 100 and System 300 include cache memory, a new memory-management board, and a 50-megabyte hard disk for prices ranging from $9995 to $19,995. Cromemco also announced a 2-megabyte RAM board for the S-100 bus, priced at $8995. . . . **Paradise Systems Inc.**, Brisbane, CA, announced a modular graphics/multifunction card for the IBM PC. The $395 base price includes either monochrome or color graphics. Memory, clock/calendar, disk-controller, and serial-, parallel-, or game-port options can also be added to the board. . . . **Seagate** and **IBM** have cross-licensed patents. . . . **Microsoft** is selling the PCjr Booster, a 128K-byte expansion board bundled with a Microsoft mouse for $495. Also included with the board is JBASIC, a faster BASIC that also takes advantage of the faster expansion-card memory. . . . **AudoPilot Co.**, Huntington, NY, announced a $459 voice-recognition board for the IBM PC. . . . **Bondwell Industrial Co.**, Fremont, CA, is selling an auto-answer 300-bps telephone-line-powered modem for $90. . . . **Alphacom** announced the Alphapro, a $400 daisy-wheel printer. Interface cartridges for the IBM PC, Apple II, or Apple Macintosh are $50 each. . . . **Western Graphtec**, Irvine, CA, announced the FP 5301, a $3000 10-pen plotter. . . . **NEC Home Electronics** announced a $199 color-display adapter and a $799 3½-inch disk drive for its PC-8201 notebook computer. . . . **Lanx Corp.**, San Jose, CA, is now producing perpendicular magnetic recording disks. The company expects to produce 200,000 to 400,000 disks per year, with full production by the end of this month. . . . **Oemtek Inc.**, San Jose, CA, will make a line of IBM PC-compatible computers to sell to other manufacturers. . . . **C. Itoh Electronics** displayed an 80-column by 25-line LCD at NCC, available for $300 in large quantities. . . . **Qume** has introduced a 90-cps daisy-wheel printer. The Sprint 11/90 costs $2695. . . . **Linear Systems Ltd.**, Winnipeg, Manitoba, Canada, announced the Scrambler, a $499 DES encryption board for the IBM PC. . . . **Orenda Inc.**, Los Angeles, CA, announced a $100 controller allowing Atari, Commodore, and Apple II computers to control a videodisc player. . . . A federal judge in Alexandria, VA, sentenced a 24-year-old **computer raider** to one year probation and ordered him to pay for connect time for illegally tapping into the GTE Telenet electronic-mail network.

From Nikkei BYTE, Tokyo: Kantodenshi has introduced a $200 optical modem, the Logitec K-741. The modem uses optical fiber to communicate up to about 100 meters.

Now, translate your integrated software into integrated hard copy, with the TI OMNI 800™ Model 855 printer. So versatile, it combines letter-quality print, draft-quality print and graphics as no other printer can.

It prints letter-quality twice as fast as comparably priced daisy wheel printers, yet gives you characters just as sharp, just as clear.

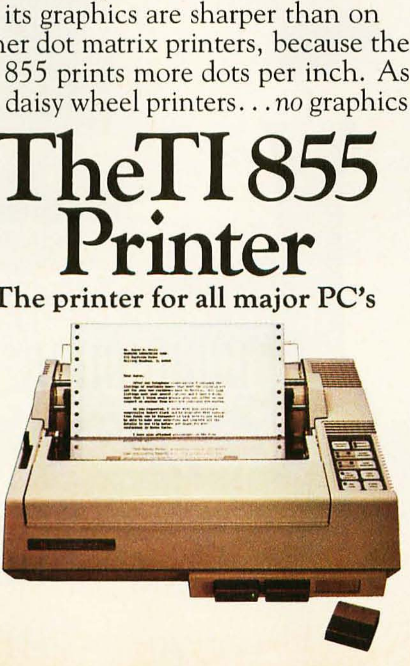
It prints rough drafts ten times faster than daisy wheel printers... faster than most any other dot matrix printer.

Only the TI 855 has snap-in font modules. Just touch a button; change your typestyle. The 855 gives you more typestyles to choose from than ordinary dot matrix printers. It makes them quicker, cleaner, easier to access than any other dot matrix or daisy wheel printer.

The 855's pie charts are rounder... all its graphics are sharper than on other dot matrix printers, because the TI 855 prints more dots per inch. As for daisy wheel printers... *no* graphics.

The TI 855 Printer

The printer for all major PC's



For under $1,000 you get twice the performance of typical dot matrix printers. Or all the performance of a daisy wheel printer, and then some, for half the price.

So get the best of all printers, and get optimum results from your integrated software. With the TI 855. See it at your nearest authorized TI dealer. Or call toll-free: 1-800-527-3500. Or write Texas Instruments Incorporated, P.O. Box 402430, Dept. DPF-182BY, Dallas, Texas 75240.

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“Dare to

TI makes the best software perform even better.

When choosing a computer, there are two important things to look for. Who runs the best software—and who runs the software *best*! That's why we're staging a dramatic country-wide side-by-side comparison against IBM™ called “Dare to Compare.”

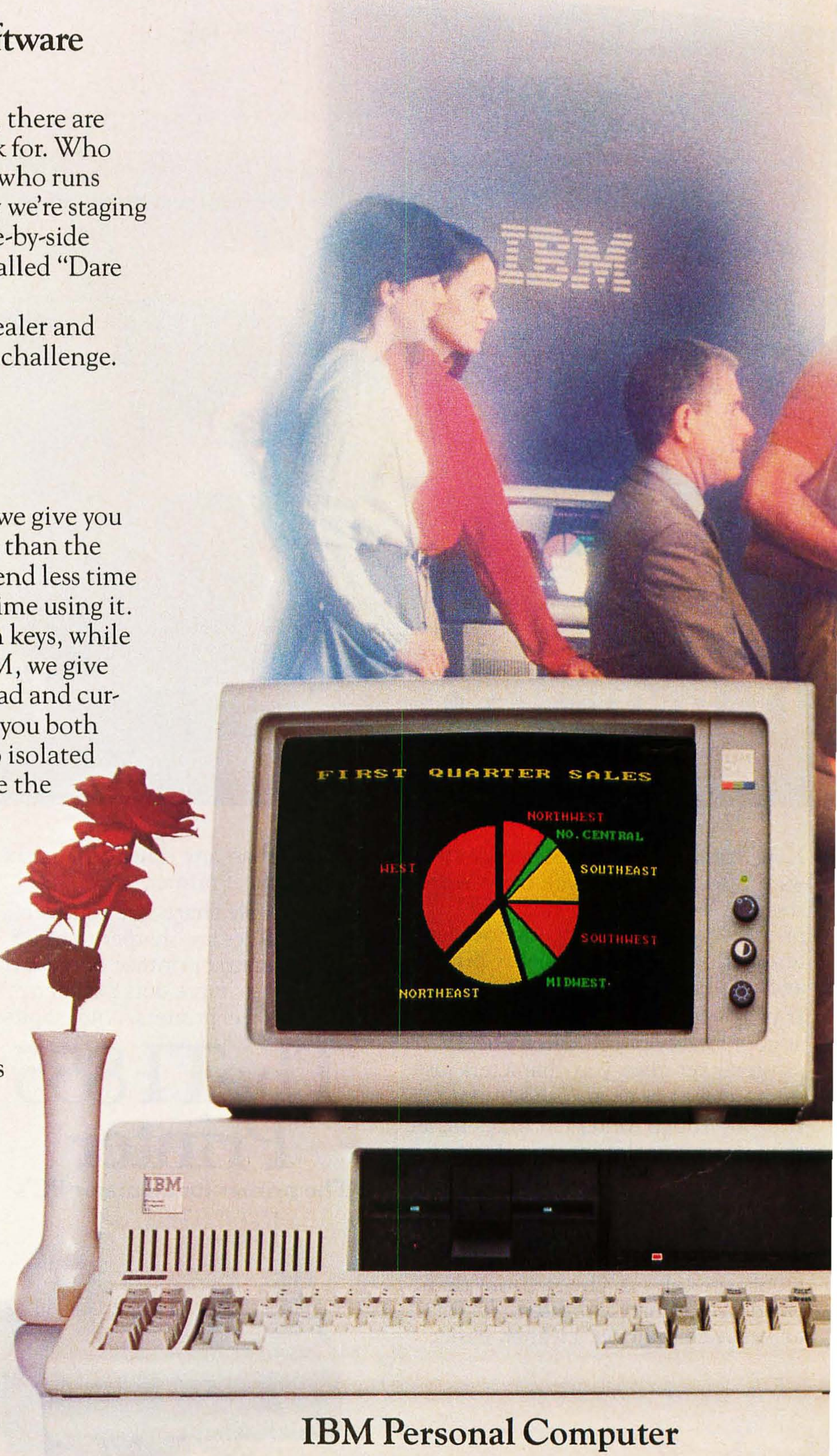
Come to a participating dealer and take the “Dare to Compare” challenge. You'll see first-hand how...

TI makes software faster to use.

Take a closer look. See how we give you more information on-screen than the IBM PC? That way you'll spend less time looking for data, and more time using it. We also give you 12 function keys, while they give you 10. Unlike IBM, we give you a separate numeric keypad and cursor controls. And that saves you both keystrokes and time. We also isolated the edit/delete keys to reduce the chance of making mistakes.

TI makes software easier to use.

TI gives you up to 8 colors on-screen simultaneously, which makes separating the data a lot easier. IBM displays only 4. Our graphics are also sharper. And easier on the eyes.



IBM Personal Computer

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FIRST QUARTER SALES BY SALES REGION
WEST 37.2%
NET SALES $12.2M
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NET SALES $5.7M
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NET SALES $2.4M
SOUTHWEST 12.4%
NET SALES $4.1M
SOUTHEAST 12.5%
NET SALES $4.2M
NORTH CENTRAL 3.2%
NET SALES $1.1M
NET SALES $3.2M
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SOUTHEAST
SOUTHWEST
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L·E·T·T·E·R·S

AN UNFORTUNATE MISSPELLING

I was reading the article "Simulation of Weighted Voting: The Banzhaf Index" by Philip A. Schrodt (March, page 138), when I noticed a strange misspelling of our prime minister's name, who, in fact, isn't "Bennito" but "Bettino" Craxi. This is both unfortunate and funny: it's unfortunate because the name "Benito" reminds Italian people of an unlucky part of their history that isn't comparable to today's democracy, and it's funny because the only other journal that "unintentionally" made such a mistake was *Pravda*, in one of its recent articles attacking our government.

Apart from this, I'd like to point out that the real Banzhaf indexes for the Italian situation are much different from the ones given by Mr. Schrodt. Mr. Schrodt did not consider several factors:

- the importance of the Italian Social Movement is very small because no one would accept its partnership
- the Proletarian Democrats would only join the Communists
- the Radicals are against everybody

Mr. Schrodt also did not consider the fact that it's the first time in 30 years that a Socialist has become prime minister.

Mr. Schrodt's attempt to simplify and symbolize political situations is interesting, but I think he should read some unbiased foreign newspapers before attempting this with countries other than his own.

PAOLO PRANDINI
Brescia, Italy

Thank you for your letter. My misspelling of Bettino Craxi's name was, of course, an error, and I can assure you that it was purely accidental and was not intended as a political statement. In fact, I had specifically looked up the spelling and I must have made the mistake when typing from my notes.

Nonetheless, I should have caught the error, particularly since I follow Italian politics closely enough to realize that this misspelling of Mr. Craxi's name has become rather popular lately in Italian publications on the left (and not just in Pravda*). I assure you again that absolutely no political statement was intended on my part, and I have no strong feelings one way or the other regarding Mr. Craxi's administration.*

Regarding the applicability of the Banzhaf index to the current strength of the Socialist party, I am fully aware that parties such as the MSI and Radicals would be unlikely to become involved in coalitions, although I would not rule these out altogether—in politics few things are impossible. The Banzhaf index is an approximation only and there are more refined techniques available to handle contingencies such as the ones you mentioned. Nevertheless, I still find it interesting that the latest election gave the Socialists greater Banzhaf power than they've had at any time in the past 20 years, and I found this fact useful.

I received a couple of other letters from Italy pointing out my spelling mistake, although the other writers assumed that the error was accidental. In fact, on the basis of the response to this article and my earlier articles in BYTE, there are many Italian and English BYTE readers. Given that, I can assure you that in the future I will be far more careful in my proofreading, and, again, my apologies for the error.

PHILIP A. SCHRODT
Clinton, NY

ON TRADEMARKS

To an impartial outside observer it would seem that the American society in general, and the microcomputer business in particular, is reaching the stage where it is based on a suerage scheme.

The ever-increasing problems caused by the proliferation of trademarks and registered trademarks must surely be an advantage to lawyers and attorneys, suerage forms at the ready, who can keep a watchful eye on witting or unwitting violators.

If the present trend continues, every word in BYTE magazine will have to include a trademark or registered mark. Ultimately, the letters TM may be trademarked, resulting in a recursive process of marking trademarked trademarks.

An alternative solution perhaps would be to print a list of all words or sequences of letters and numbers used in the relevant issue of the magazine, with a general disclaimer that any or all of the words or sequences of characters may or may not be a trademark or registered trademark.

ARNE ROHDE
Struer, Denmark

P.S. This letter, including this postscript, contains the following words or sequences of characters, any or all or none of which may be trademarks or registered trademarks of zero, one, or more companies or organizations: a, advantage, all, alternative, american, an, and, any, arne, at, attorneys, based, be, business, by, byte, can, caused, characters, companies, contains, continues, denmark, disclaimer, ever, every, eye, following, forms, general, have, if, impartial, in, include, including, increasing, is, issue, it, keep, lawyers, letter, letters, list, magazine, mark, marking, may, microcomputer, more, must, none, not, numbers, observer, of, on, one, or, organizations, outside, particular, perhaps, postscript, present, print, problems, process, proliferation, p.s., reaching, ready, recursive, registered, relevant, resulting, rohde, scheme, seem, sequences, society, solution, stage, struer, suerage, surely, that, the, this, tm, to, trademark, trademarked, trademarks, trend, ultimately, unwitting, used, violators, watchful, where, which, who, will, with, witting, word, words, would, zero.

A CALL FOR BETTER APPLE SUPPORT

I was pleased to see that Phil Lemmons is now BYTE's editor in chief. I also appreciated his editorial on ethics (April, page 4).

I have some complaints regarding Apple Computer Inc. that I hope BYTE's readership can help me with. I apologize in advance for the limited scope of the complaints and for using BYTE as a platform, but I have gotten no action from Apple despite repeated contact.

I work with several Apple users in Kansas City who have had trouble in the past several months obtaining manuals from Apple, notably *The ProDOS Technical Manual*, *Apple IIe Design Guidelines*, and *The Apple Dot Matrix Printer User's Manual*. I have, through repeated contact with Apple, come to the conclusion that the problem is at Apple, rather than at the dealers. Apple's Customer Service Department has been as helpful as possible, but it cannot overcome basic errors in maintaining availability of these vital publications. *The ProDOS Technical Manual* and *Apple IIe Design Guidelines* were out of publication until recently, and as yet I have been unable to get a verifiable delivery date from local dealers.

The ProDOS Technical Manual has been printed at least once for developers, but I attempted to order one shortly after purchasing *The ProDOS User's Kit* and was told they were out of stock and would not be reprinted until May. It is now June and they are nowhere in sight. It is not possible to do any credible machine-language programming involving ProDOS without this reference.

Apple IIe Design Guidelines is quoted in Apple's own IIe literature as a reference for programming for the Apple IIe 80-column-text cards. I have been on its trail most of this year; it is (according to my Apple dealer) out of print and unavailable until June of this year. The IIe text-

(continued)

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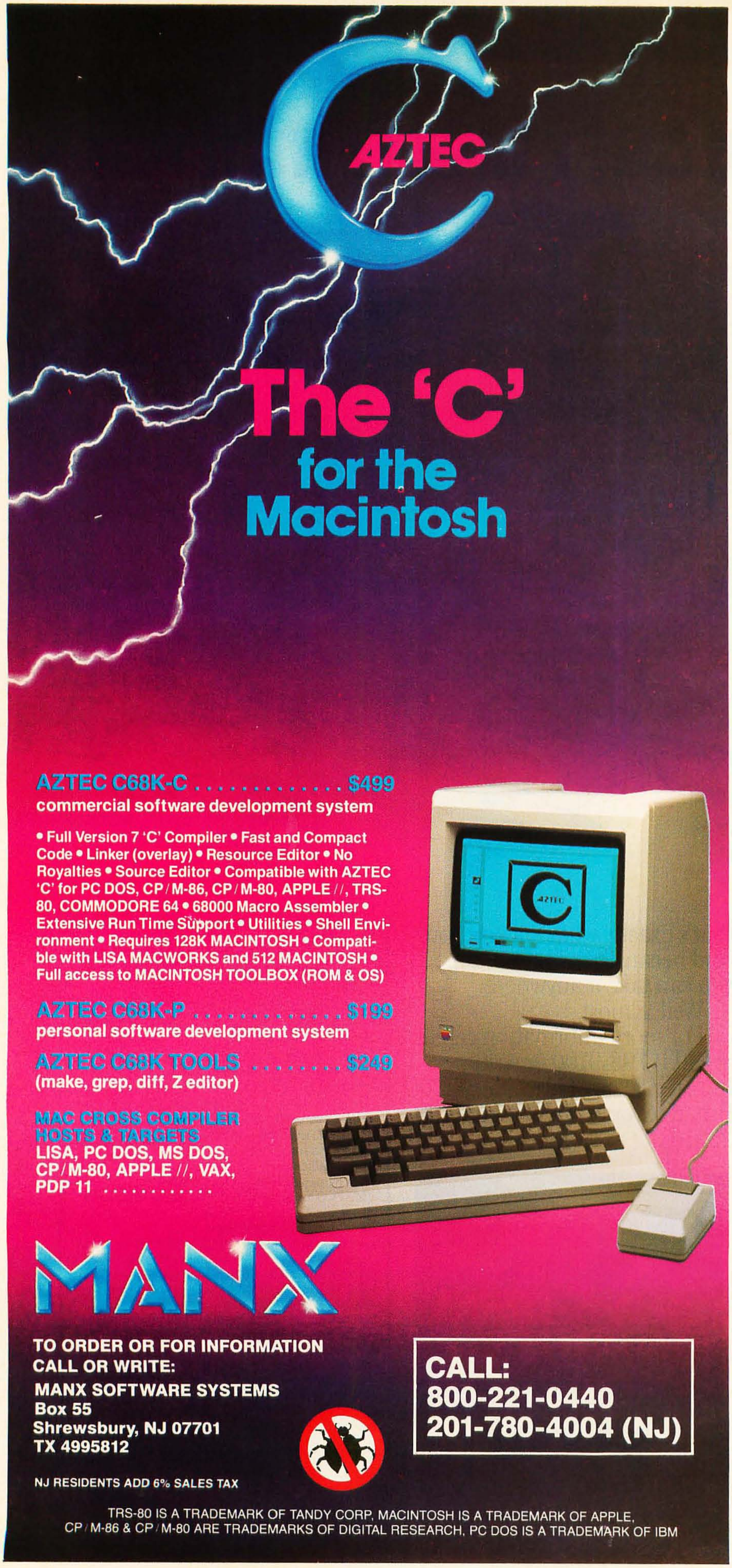

card programming is not adequately documented in Apple's other IIe manuals (as evidenced by caveats in Apple Part #031-0408-A, "Errata to the Apple 80-Column Text Card Manual").

The Apple dot-matrix-printer user's manual is often absent when you buy a printer directly through Apple. A friend of mine who bought an Apple IIc system recently found no printer manual with her Apple printer.

With Apple proffering low-level manuals such as *The ProDOS User's Manual* and *The Apple IIe Owner's Manual* in the name of user friendliness, you would think the company would not leave users to puzzle out crucial elements of their systems unassisted (it is simple to write easy-to-understand manuals if you don't say much). I don't discount the tutorial utility of *The Owner's Manual* but it is not very useful after you set up the computer. I do find *The ProDOS User's Manual*, in a word, pretentious (140 pages describing the ProDOS equivalents of MUFFIN and FID and hierarchical file structure gives credence to the phrase "wordy and verbose"). The ProDOS utilities supplied in *The ProDOS User's Kit* are useless without sufficient description of ProDOS functions to understand the environment. The book should have more closely resembled the excellent DOS 3.3 manuals, with the possible exception of a separate volume for the MLI. Apple also has unbundled the manuals and strewn information among them in a haphazard manner (the only documented input routine for the 80-column card is in *The Applesoft Tutorial*, but not in the 80-column card documents or any of the other presently available IIe manuals). Apple's review procedure is apparently not adequate.

There simply is no reason these manuals should be so hard to obtain; I have been an Apple owner since 1980, and I expect better and more responsible support from the company. I was appalled that my Apple IIe came with only *The Owner's Manual* and the DOS 3.3 manuals; I can only imagine what a nightmare it must be for those who are now purchasing ProDOS-based Apple systems essentially undocumented. My only conclusion is that Apple sells computers for their value in running "canned" programs.

I am hoping to change this. Apple's Customer Service Department will have to receive user complaints in order to bargain with Apple's Marketing Department, which appears to be the source of the problems. If you have also experienced these problems, please write to Apple Computer Inc., M/S 22, 20525 Mariani Ave., Cupertino, CA 95014, and complain if you have also experienced these problems.

DENNIS DOMS
Kansas City, MO

A READER COMPLAINS

As a librarian in a public school system I see quite a few computer magazines and BYTE is one of the best. However, the fact that IBM and Apple dominate computer sales is no reason to devote such a large percentage of editorial

(*continued*)

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space to articles dealing with these brands of computers. The suitability of a computer for a situation depends on the particular application of the computer, not its trade name.

I recently purchased my first computer and, after careful shopping, chose the Fujitsu Micro-16s, little thanks to BYTE. After screening old issues I came up with only one technical article about this system. It was just enough to spark my interest to hunt for more information. Why does BYTE basically ignore Japanese computers like Sord, NEC, and Fujitsu? The Micro-16s, with its 24-bit data bus, replaceable microprocessors, and ability to access up to 5 megabytes of keyboard RAM using the 68000 chip, is not expensive and makes the IBM PC and even the new Apple Macintosh look like a pair of plow horses. So what if it doesn't run Lotus 1-2-3—other software exists that's as good or better.

I picked my computer because it is an alternative to the IBM PC, rather than a clone. My friends and I feel that these Japanese computer systems are not only a lot different than American systems, they're a lot better.

DAVE MCCONNELL
Wichita, KS

We ran articles in June 1983 showing the great variety of 16-bit systems available, including the Fujitsu Micro-16s, and we published a review of the NEC APC in October 1983. A review of the Sanyo MBC-550 appeared in August 1984 and an article using the Sony SMC-70 appeared in July. We have also done one article on the NEC PC-8201 portable (June 1983) and have covered the Epson QX-10 and HX-20. The preponderance of articles on American machines reflects the number of manuscripts submitted about them rather than a policy at BYTE.

A SECOND OPINION ON THE SAGE

I must take exception to some of the statements Jerry Pournelle made in "Chaos Manor's Hard-Disk System" (May, page 59). Mr. Pournelle (and by reference, Rod Coleman) appears to have a strong anti-UNIX attitude. From the comments made it looks like this position results from lack of familiarity with UNIX. On page 74 Mr. Coleman is quoted as attributing the error message "Volume not on line" to UNIX; in fact this is a p-System error message. I could give many examples of user difficulty with the p-System (e.g., ambiguities such as "e" to enter the editor and "e" to exit the editor without saving the session). Users are not served by commentary on operating-system use that is not based on a reasonable degree of familiarity with that system.

Mr. Pournelle's characterization of the Sage as "the best 68000 computer available" cannot be taken seriously. The Sage is a fine 68000 computer for single-user applications, but it lacks many architectural features needed for multiuser, multitasking applications. Sage has

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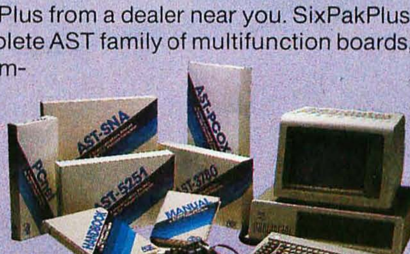

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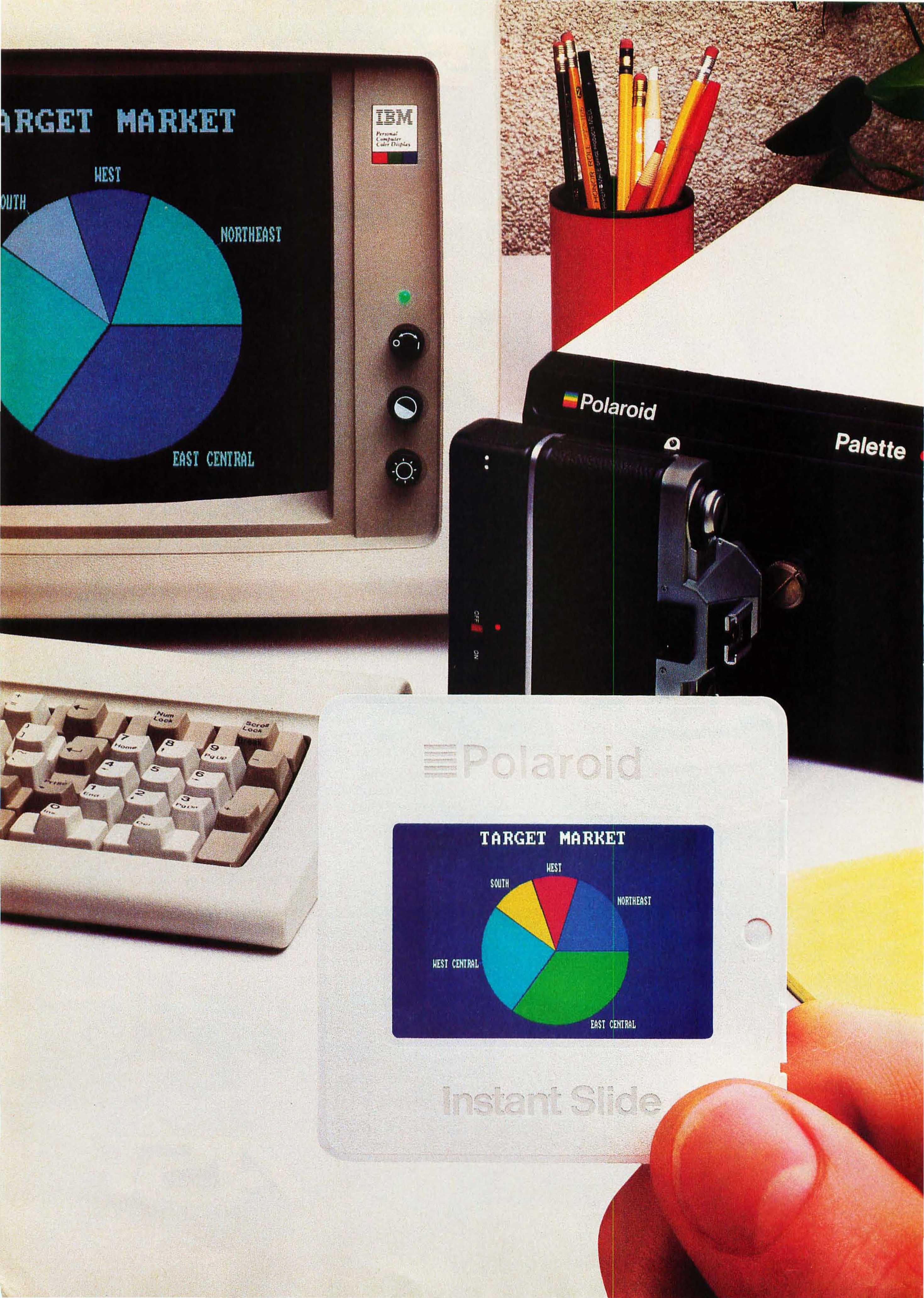
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no hardware memory management, no hardware clock that is useful for process switching, no truly intelligent hard-disk controller (forcing the microprocessor to do seeks, etc.), no independent disk-completion interrupt, and has an irregular arrangement of processor-interrupt priority levels. Our firm was the first to port Idris (Whitesmiths' UNIX-like operating system) to the Sage, and we are well acquainted with the problems these deficiencies can cause in a true multiuser, multitasking environment.

My purpose is not to put down the Sage. But given the existence of computers like Charles River Data Systems' Universe, the Dual, the NCR Tower, and the Plexus, to name just a few, Mr. Pournelle's characterization of the Sage as the "best" must be considered only personal opinion and preference; not objective technical assessment.

RICHARD L. PESKIN, PH.D.
Flemington, NJ

CHOOSING SOFTWARE FOR A DENTIST'S OFFICE

Dr. Jonathan Javitt's article "Computerizing a Medical Office" (May, page 171) covered many issues that are critical when doctors choose their first computer. However, I disagree with Dr. Javitt's contention that doctors should buy their software before their hardware. Luckily, I purchased my 8-bit computer (Xerox 820-II) prior to my software. Medical/dental software manuals adequately separated good from bad programs, but they did not show degrees of goodness. So I started buying demonstration disks with manuals. Running the program on my computer opened up many new evaluation areas to me. I found that programming language was important—a program written in CB-80 was up to 10 times faster than one written in BASIC. Program features and/or deficiencies became readily apparent. The differences among programs were great. I had to evaluate over 16 packages before selecting the one that best suited my needs. I spent up to two weeks and 12 to 20 hours on most. I have been in dental practice 28 years and can't remember when I've had as much fun.

WILLIAM E. TRACY, D.D.S.
Beaverton, OR

HANDLING THE REFLECTED VERTEX

I would like to add a few comments to the interesting article "Fitting Curves to Data" by Marco S. Caceci and William P. Cacheris (May, page 340). On page 344 the text reads, "The expanded vertex is accepted if it has a lower response than the rejected one; otherwise, the program accepts the reflected one." However, line 298 of the program indicates that "best" should have been used instead of "rejected" in the above quoted sentence.

The original article by J. A. Nelder and R. Mead ("A Simplex Method for Function Minimization," *Computer Journal*, Volume 7, page 308, 1965) gives a slightly different method for handling the reflected vertex. If the reflected vertex's response (y^*) is between the lowest response (y_l) and the *next to lowest* response (y_n), then the reflected vertex is accepted. If y^* is between y_n and the highest response (y_h), then the vertex coresponding to y_h is replaced by the reflected vertex (which becomes the new vertex with the highest response). Then you proceed to contraction or shrinkage. Ironically, there is a discrepancy between Nelder and Mead's text and their flowchart, just as there is a discrepancy between the article's text and program.

JAMES TURSA
Austin, TX

The original article by Nelder and Mead proposes a slightly different algorithm for simplex movement than our article. In their article, they differentiate between movement by reflection and contraction (when reflection does not produce a new "best vertex") by comparing the reflected vertex response. Thus, Nelder and Mead's test is consistent with their flow diagrams. Our simplex algorithm differs from Nelder and Mead's in use of the "next-to-worst" vertex in simplex movement. We simply do not search for the next-to-worst vertex on every iteration and accept the reflected vertex if it lies between the best and worst vertex (not between the best and next-to-worst vertex as proposed by Nelder and Mead). Thus our code is simpler and faster than the original while maintaining efficient simplex movement.

On page 344, the word "rejected" was inadvertently used instead of the correct word "best." This is readily apparent from inspection of both our flowchart and program listing, which show that an expanded vertex is accepted only when both it and the reflected vertex are better than the current best vertex.

WILLIAM P. CACHERIS
Tallahassee, FL

BINARY TREES EXPLAINED

In his article "Indexing Open-Ended Tree Structures" (May, page 406), John Snyder provided a novel but complex solution to a simple and well-understood problem. Despite my nine years of experience programming computers, I had considerable difficulty deciphering his article. Let me present the proper solution as described by D. E. Knuth in *Fundamental Algorithms*, section 2.3.2, "Binary Tree Representation of Trees."

The tree representation is merely a collection of nodes and their links. For each node, only two links will be provided. The links will be (1) a pointer to the first child node, and (2) a pointer to the sibling node immediately to the right. The terms "child" and "sibling" are used here to illustrate the relationship between the nodes in exactly the manner of a family tree. To demonstrate the use of the links in this representation, consider the selection of the *I*th child of a particular node: first, the pointer to the first child node is used, then the pointer to the next

Listing 1: (*a*) A *structure to represent data and links in each node;* (*b*) *the search routine.*

```
(a) struct node {
        struct node *child;    /* pointer to 1st child */
        struct node *sibling;  /* pointer to next sibling */
        /* data for node */
};


(b) /* search for an element in a tree:
        tree is a pointer to the root node of the tree,
        subs is a list of subscripts (counting from 1), 0 terminated
        returns a pointer to the desired element, or NULL if the
        element does not exist */
struct node *search(tree, subs)
struct node *tree;
int *subs;
{
        int i;
        for (; tree && *subs; subs++)
                for (tree = tree->child, i = 1; tree && i < *sub; i++)
                        tree = tree->sibling;
        return (tree);
}
```

sibling is used repeatedly until the *I*th child is reached.

In the C programming language, a structure is used to represent the data and links for each node (see listing 1a, presented here).

Null pointers are used to indicate terminals: a null child pointer indicates that there are no lower levels and a null sibling pointer indicates that this is the last item at this level. Thus the search routine is shown in listing 1b. Insertion and deletion from such a tree is also simple. If one does not have the benefit of pointers and structures, there are alternatives. Pointers may be replaced with array indices and an array of structures may be replaced with an array for each structure member.

Lawrence Leinweber
East Cleveland, OH

I take issue with anyone presenting "the proper solution" to any problem—the world just does not work that way, and neither does programming.

I am aware of binary trees. They are sometimes called B-trees, part of the fun of calling mine A-trees. I expected most, if not all, of my readers to also be aware of binary trees. So I did not feel it necessary to mention them. If this assumption was incorrect, I appreciate Mr. Leinweber's review.

I do not claim to be a computer scientist. I like to think of myself as a problem solver. When confronted with an application where binary trees seemed to be overkill, I searched for and found what I believe is an interesting and useful alternative, especially if tree updating is infrequent. I refuse to believe that A-trees are more "complex" than binary trees—personally, I find them simpler.

I particularly like the applicability of my 8088's string-scan instruction (mentioned in the article but, unfortunately, not illustrated in the sample programs). Once you know the value you are looking for, you execute one (repeated) machine instruction to get you there.

The mathematics of the search algorithm is also interesting to me. In fact, I have pursued tree-manipulation methods based upon the "difference table," such as tree sorting and "normal forms" for trees.

In the meantime, I will not be deterred from my efforts, both to develop ideas and to share them with others. After all, isn't that what programming is all about?

John Snyder
Baltimore, MD

More on User Friendliness

I commend both you and William J. Raduchel for your courage. Defining the term "user friendly" is no mean feat (see "A Professional's Perspective on User Friendliness," May, page 101). I also commend Mr. Raduchel for his efforts—with some significant reservations.

Mr. Raduchel's article does a doggone good job of isolating the impact of a large number of factors present in the computer work environment. And there can be little question that his math skills are impressively demonstrated in his attempt to quantify user friendliness. But I fear he is in the doghouse with me because of his hyperanalytical approach.

"User friendly" is a simple phrase. The meaning of the phrase is not locked up in a mathematical netherworld that can only be penetrated with the precisely made points of mathematics. For true meaning, we need only look to the simple visual images evoked by each of the words in the phrase.

A "user" is one who uses—in this case—a computer. The word "user" is being used to modify the meaning of the second word in the phrase—"friendly." Friendly to what? Friendly to the computer/software user. It is not hard to visualize a person using a computer.

(continued)

Nor is it hard to visualize a friend. Dog is man's best friend. We can assume that a computer must have at least some of the unique behavioral characteristics of a beloved pet dog in order to be considered "friendly." We need only answer one question to savor the full richness of the phrase: What is unique about a dog's behavior toward man that makes dog man's best friend?

The answer to this question is really quite simple. The dog:

1. Always does what it is told.
2. Never bites its master.
3. Is always very sorry when you yell at it.
4. Is exceptionally eager to please.
5. Doesn't eat too much.

One point I agree with is Mr. Raduchel's assertion that the definition of "user friendly" is dependent upon the user group. After all, everybody likes a dog that fits their temperament. But that doesn't change the fact that the dog had better have the five traits already listed.

I would submit that the problem with most computers and software is that they are made in the maker's image. We all know that this won't work out. Frankenstein taught us that. What we need to do is start making computers and software in the image of the dog. Or perhaps we need to let dogs design software and computers.

What we don't need are any more doggedly determined efforts at quantifying abstract constructs such as "friendliness." After all, when was the last time your kids picked a dog out of the pound by first regressing the number of wags of its tail per minute against their own heartbeat?

In short, I think Mr. Raduchel should have answered "yes" when he rhetorically asked if user friendly were "another . . . useless 'I don't know how to define it, but I know it when I see it' phenomenon." It may be that some possessed Pavlovian personality will hound this phrase until it succumbs to a logically sterile definition. But Mr. Raduchel's dogmatic tail-chasing left me dog tired and howling at the moon.

WOODROW F. DICK JR.
Springfield, VA

Formal analytical models of abstract concepts have their very real limits, but they also have their very real value. The article was a first attempt at a difficult subject, and I have reservations myself about quantifying user friendliness. But a model does help us see clearly some of the factors at work, so I take exception with Mr. Dick's remarks. I agree with him that many programs are in their maker's image, and so we do need standards by which to evaluate them. This model is one step, I hope, on a path to those standards.

WILLIAM J. RADUCHEL
New York, NY

As a software designer and developer, I found William J. Raduchel's article most thought-provoking. The idea of developing a mathematical, experimentally testable model of "user friendliness" is certainly an important one, although it seems to me that the usefulness of this model is necessarily dependent upon the development of methods for assigning concrete values to P_0 and p_i.

However, as a user of Apple's Lisa, I must point out that Mr. Raduchel shares two misconceptions common to long-term computer users who are not well acquainted with the Lisa Office System.

The first is expressed in his statement that "Microcomputers. . .permit broader use of such *esoteric* [my italics] tools as graphics." By no stretch of the imagination can graphics, per se, be considered esoteric. Graphics, even icons, are much more widely understood than are letters from some alphabet assembled into words in some language. In the context of current computer technology, graphics are esoteric only because there are so few systems that allow them to be used as easily as alphanumerics. It is certainly arguable that graphics should be

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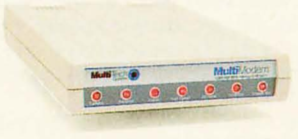

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*Titles available on IBM PC jr. are Ms. Pac-Man, Centipede, Donkey Kong, Moon Patrol[7] and Typo Attack. Available on the VIC 20 is Typo Attack.

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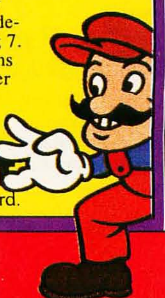

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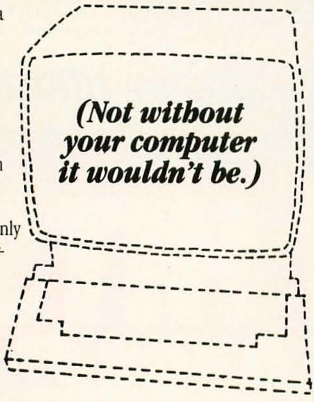

the *standard* "gateway" to a computer, and alphanumerics the exception.

Second, in his discussion of limitations on the user friendliness of integrated systems, Mr. Raduchel suggests that the attempt to make a system friendly inevitably leads to an increase in the number of steps required to operate it, that there is an unavoidable trade-off between the ease of learning a system and the ultimate ease of using it: "There are limits to spoonfeeding. . . .The effect of this is to raise both p and n by requiring many steps to do anything." Many software developers recognize the desirability of providing "shortcuts" for advanced users (for example, the optional "apple-key" forms of many Lisa menu commands). Furthermore, as users become more experienced on any system, they discover their own more efficient methods of accomplishing common tasks.

Perhaps the best demonstration of this would be a rewrite of the script given in the article for a Lisa user performing a typical task. With experience, the Lisa user could reduce this task from 30 steps to 16:

1. Double-click on a general-purpose LisaTerm document to open it. If you perform a task but don't need to keep the results permanently, it is easy to make a general-purpose document for that task and overwrite the previous contents every time you use it.
2. "Assumed" format conversion.
3. "Range." (I assume this means "select data to be cut.")
4. Cut.
5. Set aside (LisaTerm document).
6. Double-click on a general-purpose LisaCalc document to open it. This document already contains the formulas and formatting to be used in processing the data obtained. It also still contains yesterday's data, which will be overwritten.
7. "Range." (I assume this means "select insertion point.")
8. Paste.
9. Calculate. (Actually, by default this step is automatic.)
10. "Range." (Again, I assume this means "select data to be cut.")
11. Cut.
12. Set aside (LisaCalc document).
13. Double-click on a general-purpose LisaGraph document to open it. As before, this document still contains yesterday's data, which will be overwritten.
14. "Range." (Select insertion point.)
15. Paste.
16. Set aside.

There is no reason for the "erase" steps, since all of these documents will be used again tomorrow. In many cases, it is possible to reduce the three "Set aside" steps to one "Set aside everything," which would reduce the total n to 14.

The net effect of the above simplification is to increase p_i from 0.860 to 0.923 and F from 0.817 to 0.877—a substantial improvement in both parameters as a result of user experience.

On the contrary, I note that the number of

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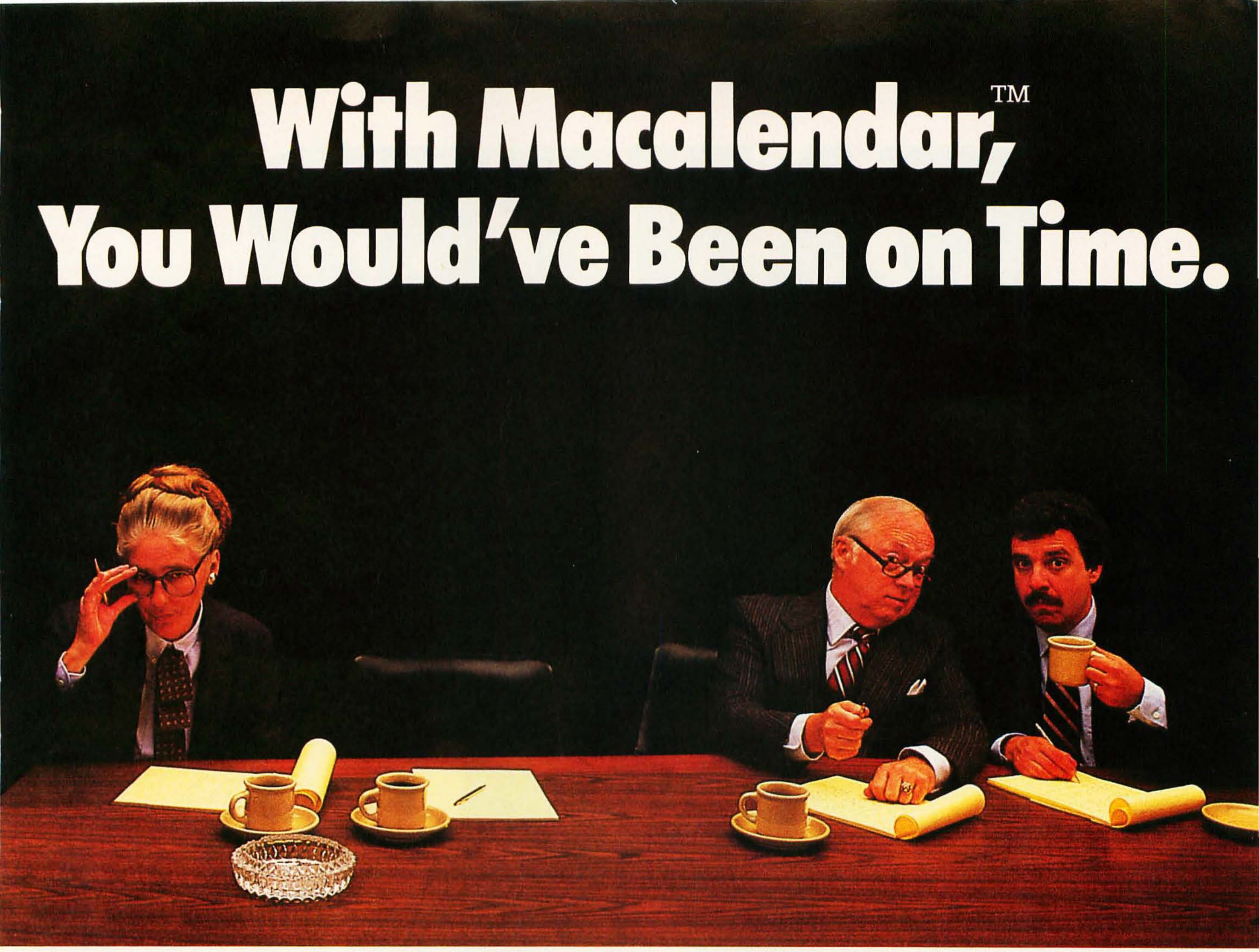

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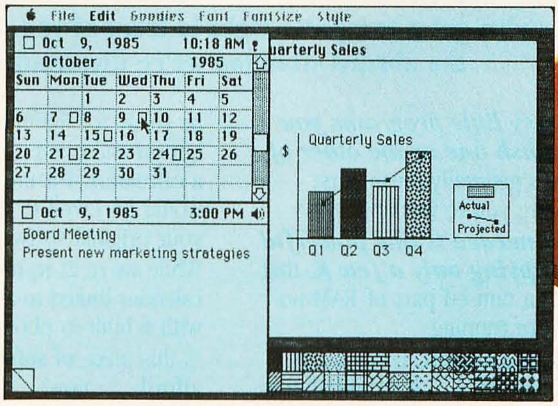

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LETTERS

steps in the "Standard PC" case seems to be irreducible.

Al Evans
Austin, TX

Mr. Evans has me, I suspect, on ways to simplify the Lisa process, but I think the fact that a more experienced user can improve on the process is in itself a comment on user friendliness. I agree with him that graphics should not be esoteric; my use of the word reflected only the reality today. Finally, I agree that long-run user-friendly systems, to coin a phrase, must provide a process to accommodate users' learning by doing.

William J. Raduchel
New York, NY

William J. Raduchel's article on user friendliness presented a useful conceptual model for the design of easy-to-learn/easy-to-use software. He has correctly recognized that wide acceptance of computer solutions to routine professional problems partly depends on obtaining accurate solutions in less time and with less expense than available alternatives. He notes that the user must recognize that a problem can be solved before the system arranged for its solution can even be entered, but he seems to concentrate on the number of steps or actions that must be taken to reach the desired end product as the basis for comparison between design alternatives. Mr. Raduchel minimizes the "Tinkertoy" approach symbolized by Lisa technology.

I suggest that the obviousness of an available solution may be a more important component of user friendliness than the number of steps. Beginning a problem-solving sequence is often the most difficult step, and, provided that subsequent steps are not obscured by the user-interface design, beginning work on a problem will ultimately lead to an acceptable conclusion in most cases. I doubt the number of keystrokes needed to reach an acceptable solution is a noticeable factor in a user's perception of user friendliness within rather wide limits. Software designers and human-factors specialists may count keystrokes to the exclusion of other important variables; users simply do not. As I believe the author is aware, it is what the keystroke accomplishes and whether it is functional within the problem-solving sequence that is important.

Users are the best judge of ease of learning and ease of use. They will tell designers what to do if their choices are observed carefully. An important principle of psychology is that choice, or the allocation of time among concurrently available alternatives, is a function of the relative frequency of positive feedback or success to the individual. In a problem-solving situation, this should translate as a function of the perception of immediate and discernible progress toward the goal. This implies that software that requires frequent actions outside of the problem-solving sequence will be less preferred (such as passing through a menu that must first be called up, inserting control characters in a word-processing program, changing disks man-

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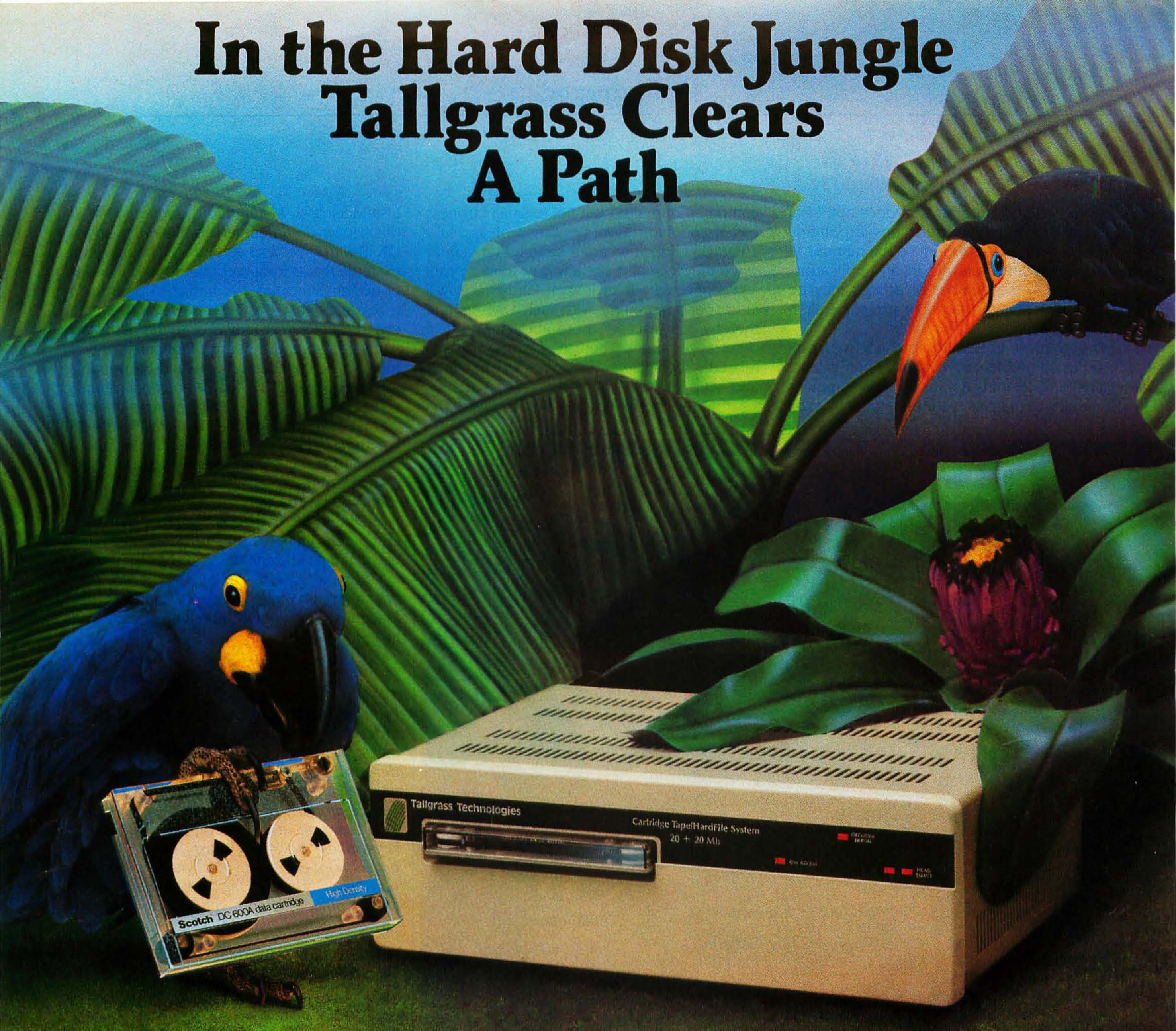

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ually, etc.) than a program that does not. Lisa/Macintosh technology uses icons, a pointing device, and windows to reduce the number of actions that are irrelevant to an application, even though the number of actions may be greater than might be possible with some alternative design.

The greatest irrelevancy prospective computer-using problem solvers encounter is manual reading. Reading a book about a computer is relevant to magazine editors, students, even computer journalists, but not to small business owners, administrators, or other professionals. They will choose to use a system that seems, when they look at it, like a way to solve a problem connected with their work. Further, they will later spend more time with such a system and thereby will discover more about using it in other applications. The use of icons and task-related screen-display design is a way to attract and keep such users.

Software is not independent of hardware. The Lisa/Macintosh system is a good example of this. However, an earlier machine, the Epson QX-10 with its Valdocs software, is another good example that is frequently overlooked in terms of design principles. I've had the opportunity to observe that computer-naive and experienced users consistently choose this hardware/software alternative in a professional environment to execute tasks that would be possible with other readily available—and concurrently unused—machines, but at a higher cost in terms of task-irrelevant actions. The QX-10 with its functionally labeled system keys on the HASCI keyboard, its simple and mostly nondistracting menu system and task-related terminology, just seems to be the right choice when users are more interested in their applications than their computers. Its ease of learning captures naive users and its relevant design keeps them coming back. I suspect Apple Computer Inc. had something like this process in mind with the Macintosh, a point that IBM and its emulators have missed.

JAMES A. MULICK, PH.D.
Columbus, OH

I concur with Dr. Mulick's general observations. Indeed, P_0 *was included in the model to incorporate many of the obviousness factors he describes, and his remarks reinforce the general superiority of a menu-form-script interface properly developed to solve problems. I do feel that at some point the number of keystrokes inevitably must matter. Experienced word-processing evaluators count them very carefully, and a long sequence is inherently less obvious than a short one.*

WILLIAM J. RADUCHEL
New York, NY

REQUEST FOR HELP

I just bought the May BYTE and thought I would tell you that I found it the best of your efforts.

The editorial ("The BYTE Reader: Who You Are") was informative; however, I wonder where I would fit in as far as your statistics are concerned.

I own a Franklin, an Apple, and a Teleram. I put in my office system for invoicing, inventory, sales commissions, and purchase orders.

I'm age 60; no college, no degrees, no electrical, no mechanical, no science; taught myself programming in Applesoft and Microsoft BASIC and dBASE II.

The only thing I don't understand is how to change a BIOS and write drivers in CP/M. I am inclined to believe that CP/M is one of the best-kept secrets in the industry.

WAYNE C. PRIDE
Hasbrouck Heights, NJ

With regard to how you fit into BYTE's reader profile, we must confess that statistics fail to capture the essence of all our readers.

For more BIOS and driver information, try Microcomputer Operating Systems *(1982) and* BYTE Guide to CP/M-86 *(1984) by Mark Dahmke (New York: BYTE Books).* ■

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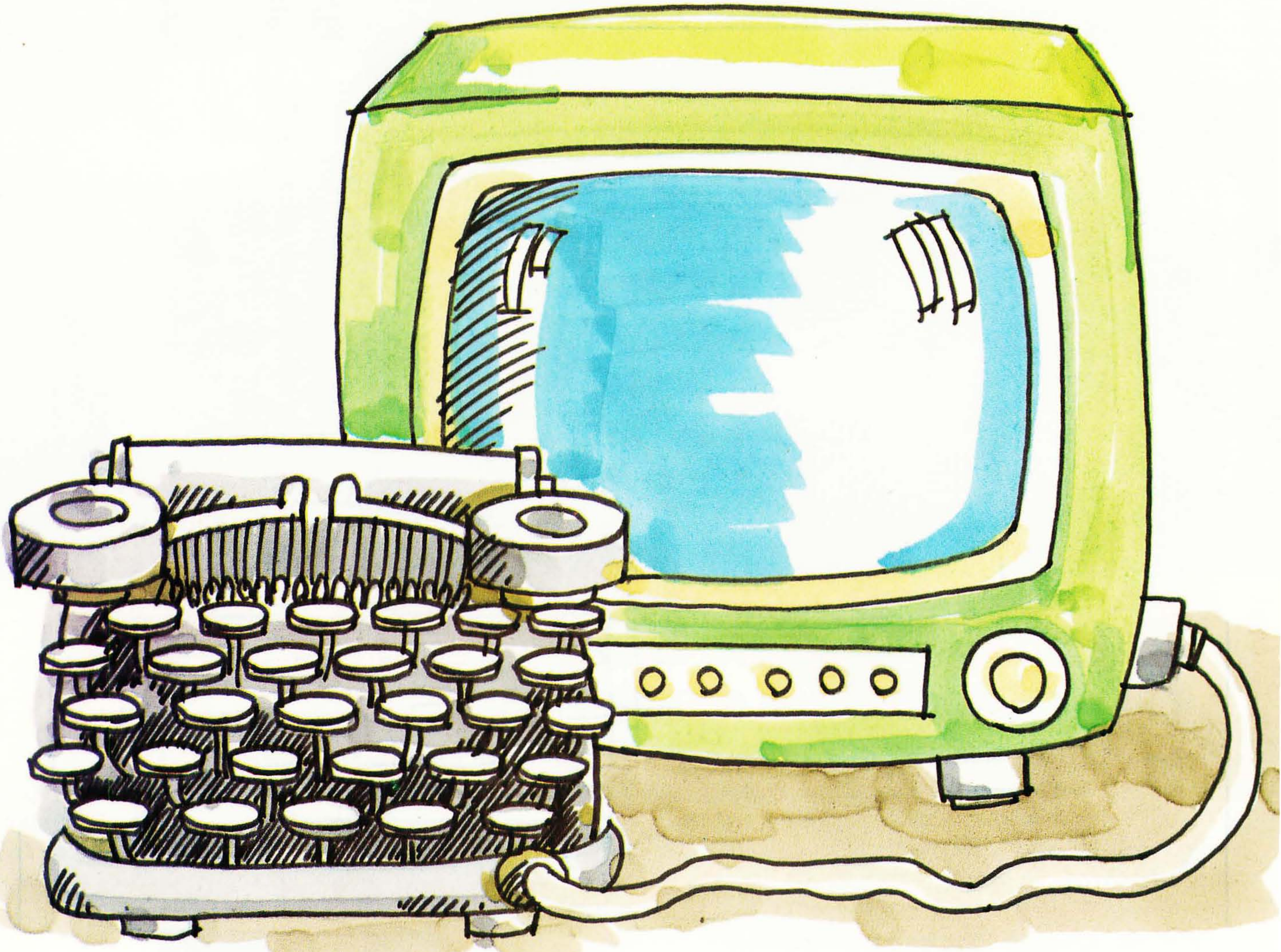

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BYTE'S BUGS

April Goofs: The Joke's on Us

Well, we were April foolish.

In James Isaak's April BYTE article, "Designing Systems for Real-Time Applications," we used the wrong captions for figures 1 and 2. (See pages 129 and 130.) The correct captions are boxed here.

The captions that did appear in the April BYTE are correct for figures A and B below, which we present to you now. These figures refer to the flow of interrupts and the servicing of those interrupts.

We apologize to Mr. Isaak and to you for this blunder. Ah, "April is the cruelest month."

Figure 1: *A breakout of the UNOS system structure showing the relationship of the real-time kernel to the UNIX-compatible environment.*

Figure 2: *A breakout of the bus structure for the Universe system that shows the uses of multiple buses and processors to increase throughput.*

(continued)

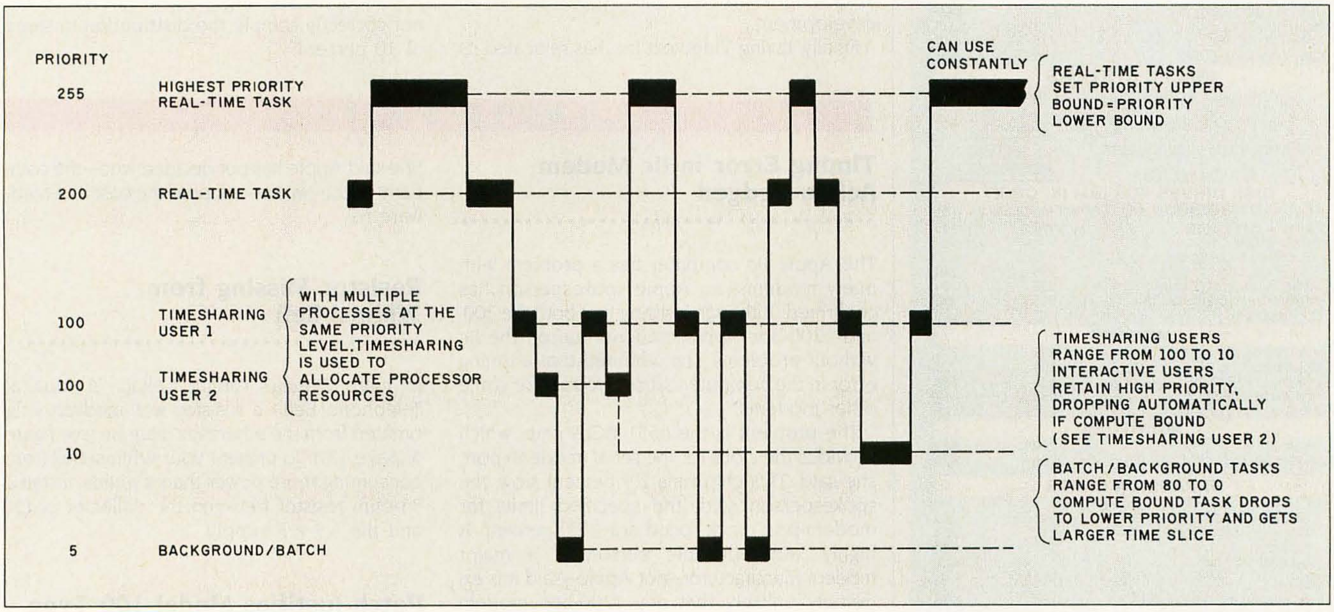

Figure A: *An example of task scheduling by the UNOS operating system.*

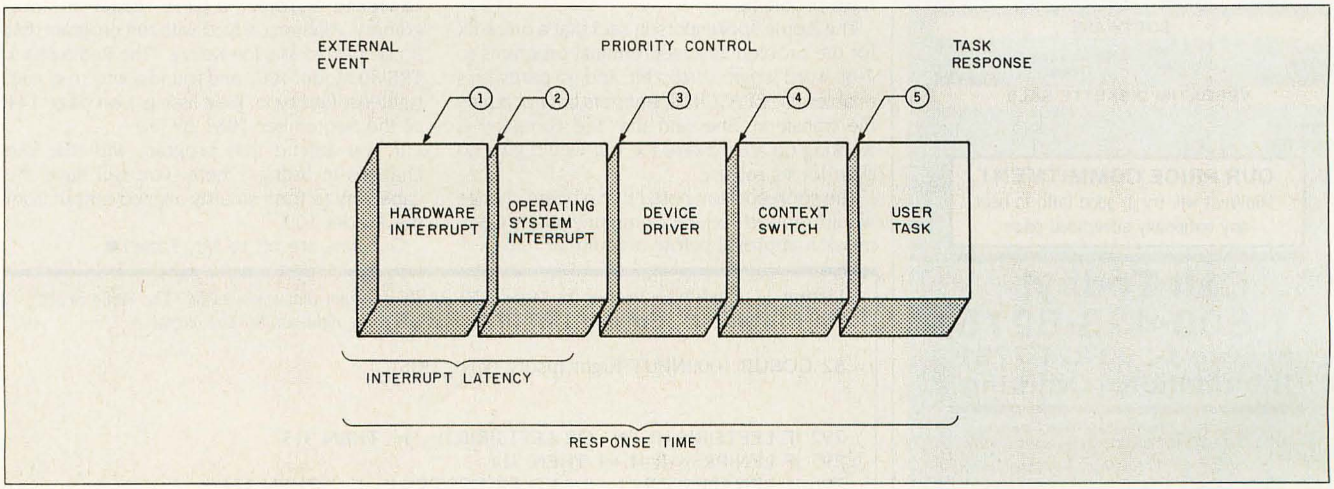

Figure B: *The components of delay in a computer as it attempts to respond to a real-time event.*

Memory Lapse

Alice C. Lankester, manager of sales promotion for Living Videotext, sent us a letter pointing out a mistake in the "At a Glance" box accompanying William R. Hershey's software review, "ThinkTank." (See the May BYTE, page 189.)

The IBM Personal Computer version of ThinkTank requires a minimum of 256K bytes of memory, not 64K bytes as stated in the article. Also, ThinkTank for the Apple II, II+, and IIe computers will run with 64K bytes of RAM, but the Apple III version needs 128K bytes.

ThinkTank for all models of the Apple computer is $150; for the IBM PC, it's $195. The "At a Glance" box also mentioned that ThinkTank would soon run on the 128K-byte Macintosh. That version is now available. It's called ThinkTank 128, and its suggested retail price is $145. ThinkTank for the Apple IIc is in development.

Finally, Living Videotext Inc. has relocated its offices. The new address is 2432 Charleston Rd., Mountain View, CA 94043. The telephone number is (415) 964-6300.

BASIC Line Changes Correct Steps

While working with the BASIC program that Pat Macaluso presented in "A Risky Business—An Introduction to Monte Carlo Venture Analysis," Eric Hilbert found a couple of bugs. (See the March BYTE, page 181.) Please make the following corrections:

```
43020 PF=NS/10
43030 FOR I=0 TO 10 :
CD(L,I)=OU(INT(I*PF+0.5))
```

Without these changes, subroutine 43000 will not correctly sample the distribution in steps of 10 percent.

BYTE'S BITS

Timing Error in IIc Modem Acknowledged

The Apple IIc computer has a problem with many modems, an Apple spokesperson has confirmed. Although insisting that both the 300- and 1200-bps Apple modems run on the IIc without problems, she admitted that a timing error in the computer causes trouble for some other modems.

The problem is the 6551 ACIA chip, which provides the clock for the serial (modem) port, she said. This chip runs 2.9 percent slow, the spokesperson said; the specified limits for modem-port clock speed are ±2.0 percent. A highly knowledgeable person at a major modem manufacturer—not Apple—said it is extremely unlikely that any 1200-bps modem would be able to cope with the IIc's speed variation and that some 300-bps modems could have problems.

The Apple spokesperson said that a quick fix for the problem is to set terminal programs to 7-bit word length, 1 stop bit, and no parity (this enables use of ASCII file transfers but not binary file transfers). She said that the company is working on a hardware fix, but would give no date for its release.

The spokesperson noted that a board change would require Federal Communications Commission approval before it could be released. She said Apple has not decided who—the company or the owner—will bear the cost of a hardware fix.

Resistor Missing from Whimsi-Bell

In July's Ciarcia's Circuit Cellar, "A Musical Telephone Bell," a resistor was inadvertently omitted from the schematic diagram (see figure 5, page 131). To prevent your Whimsi-Bell from consuming more power than it needs, install a 33-ohm resistor between the collector of Q1 and the +5-volt supply.

Patch Justifies Model 100 Type

Lawrence A. Tomei, a BYTE reader in Montgomery, Alabama, toyed with the program that accompanied Mahlon Kelly's "The Radio Shack TRS-80 Model 100" and found a way to obtain right-justified type. (See listing 1 on page 144 of the September 1983 BYTE.)

If you amend that program with the line changes in listing 1 here, you will have the capability to form smartly aligned output from the Model 100.

Our hats are off to Mr. Tomei.■

Listing 1: *Include these lines in the Model* 100 BASIC *program that appeared in* "The Radio Shack TRS-80 *Model* 100" (*September* 1983 BYTE) *and you'll get right-justified text output.*

```
82 GOSUB 100:INPUT"Right Justify (Y/N) ";RJ$


292 IF LEFT$(RJ$,1)="N" OR LEFT$(RJ$,1)="n" THEN 315
295 IF LEN(PR$)=R-L+1 THEN 314
296 IF LEN (PR$)<R-L-8 AND RIGHT$(PR$,1)=" . " THEN 314
297 IF LEN(PR$)<(R-L)*3/4 THEN 314
```

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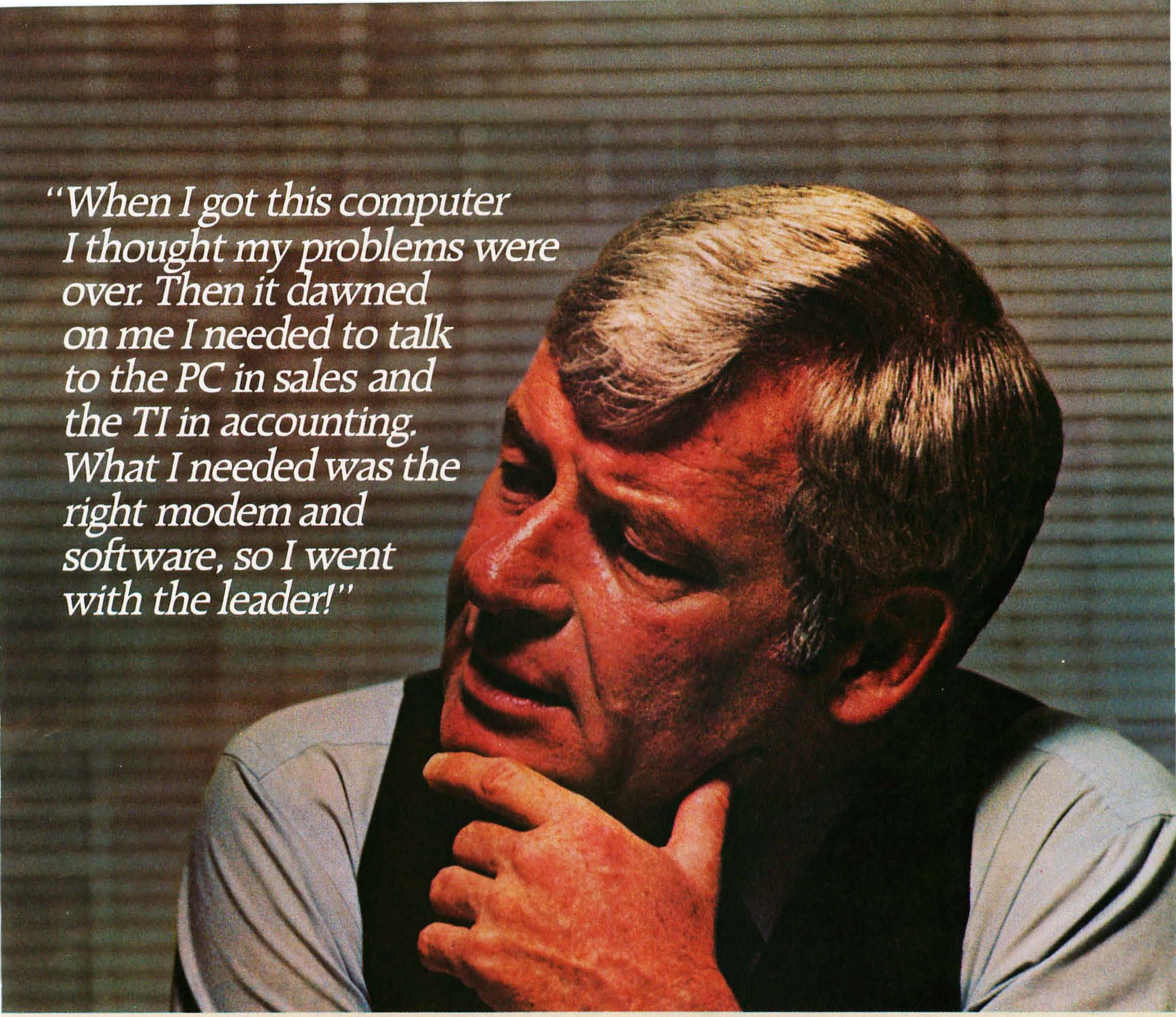
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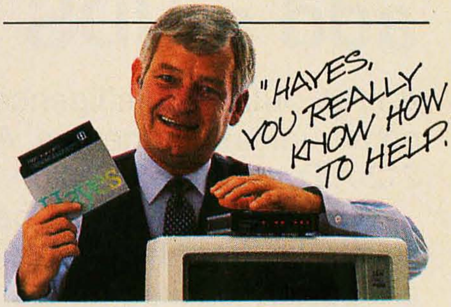
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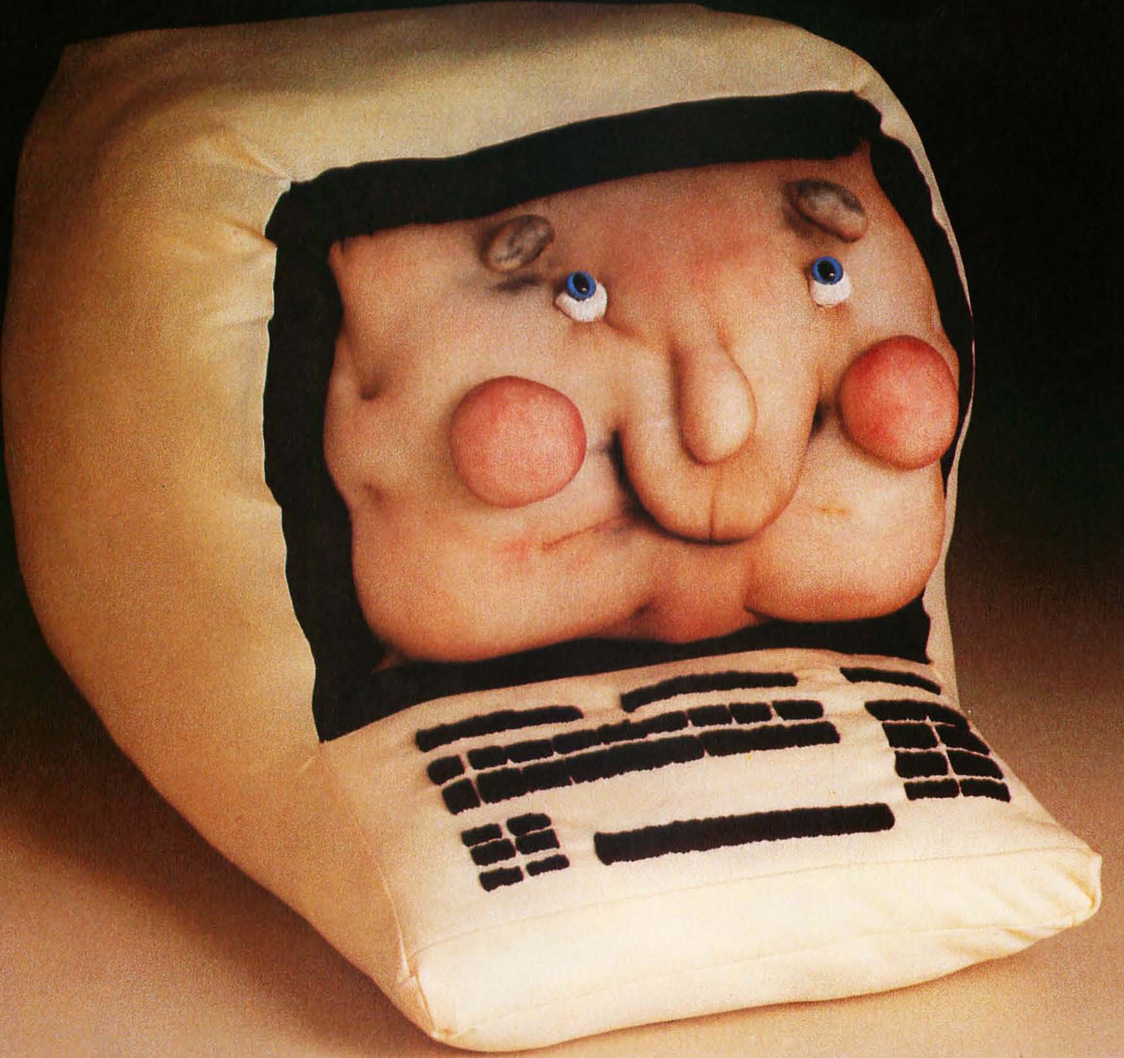

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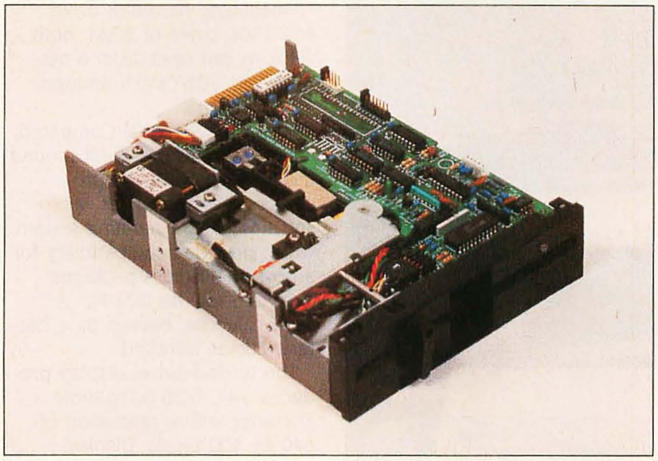
Half-Height Drives Feature Self-test



Omek Corporation's OM5X family of half-height, double-sided 5¼-inch floppy-disk drives are designed for applications where removable data storage is a priority. A unique feature of these drives is their built-in self-test and exercise functions.

The self-test/burn-in mode allows the drive's microprocessor to cycle through and monitor the spindle speed and the circuitry associated with the spindle, the write-protect mechanism, and the index. The alignment mode lets you adjust the spindle speed without an oscilloscope, frequency counter, or other monitoring equipment.

A two-color front-bezel LED is used to indicate conditions during the self-test, burn-in, or alignment modes. The LED will indicate the following failures: speed out of tolerance, stepping breakdown, and write-protect out of sync. In alignment mode, the LED shows fast, slow, or correct spindle speed.

The OM5X's microprocessor controls motor start, write current switching, stepping for reduced head-positioning hysteresis, and the self-test/exercise modes.

The OM5X family gives you unformatted storage capacities of 500K bytes and 1 megabyte, with track densities of 48 and 96 tpi, respectively. The dimensions are 1.625 by 5.75 by 8 inches; each drive weighs slightly less than 3 pounds.

Final pricing for the drives was not established at press time. A company spokesperson, however, estimated that the 500K-byte OM55 drive would cost approximately $200 and the 1-megabyte OM56 would be around $220. Contact Omek Corp., 44844 Grimmer Blvd., Fremont, CA 94538, (415) 490-7173.

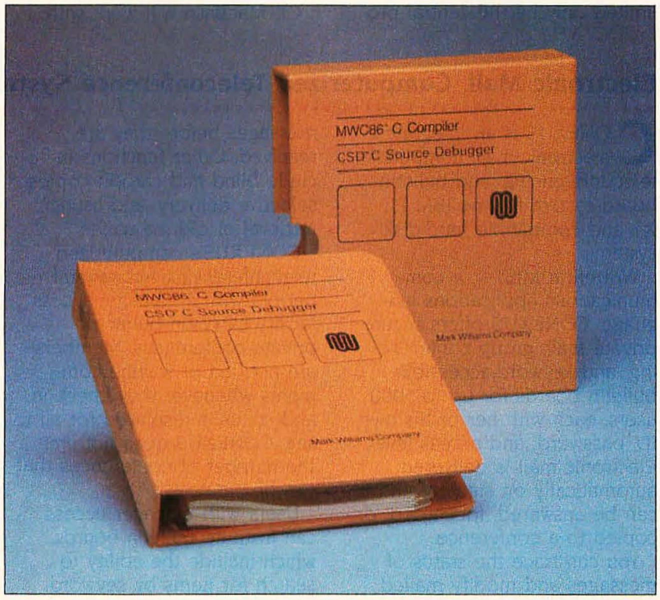
Circle 600 on inquiry card.

C Compiler/Debugger Works with MS-DOS

The MWC86 C compiler from the Chicago-based Mark Williams Company runs under MS-DOS 2.0 and comes with the csd C Source Debugger. The compiler and debugger retail for $500 and are shipped together as a single product.

Although the csd Source Debugger gives you a full debugging environment at the C source level, a thorough understanding of your assembler or hardware architecture is not required. A windowed screen lets you view the program source, program output, the value of variables, and breakpoint history. You can set breakpoints on lines of source code or program variables. The breakpoints let you stop program execution at specific lines or when the value of a variable has changed.

As the program executes, you can watch the values of variables dynamically change, and you can decrease or increase a variable's value. The target program can be executed one line at a time, or to the next breakpoint, the end of the current function, or the end of the program.



The csd Debugger also lets you watch your program execution in real time, scroll through your source code as it executes, and display values as variables change. On-line Help screens explain all debugging functions. You can customize the csd Debugger for your specific applications.

The MWC86 C compiler supports the full C language and full MS-DOS 2.0 path names. It also supports operating system calls and high- and low-level UNIX and MS-DOS system calls. Redundant and unused code is eliminated. Single command-line statements invoke all phases of the compiler, disk operating system, or other Mark Williams linkers.

System requirements are an IBM Personal Computer with a double-sided, 360K-byte floppy-disk drive and MS-DOS 2.0. Minimum memory requirements are 256K bytes or 128K bytes for the compiler alone. For further information, call or write the Mark Williams Company, 1430 West Wrightwood Ave., Chicago, IL 60614, (312) 472-6659.

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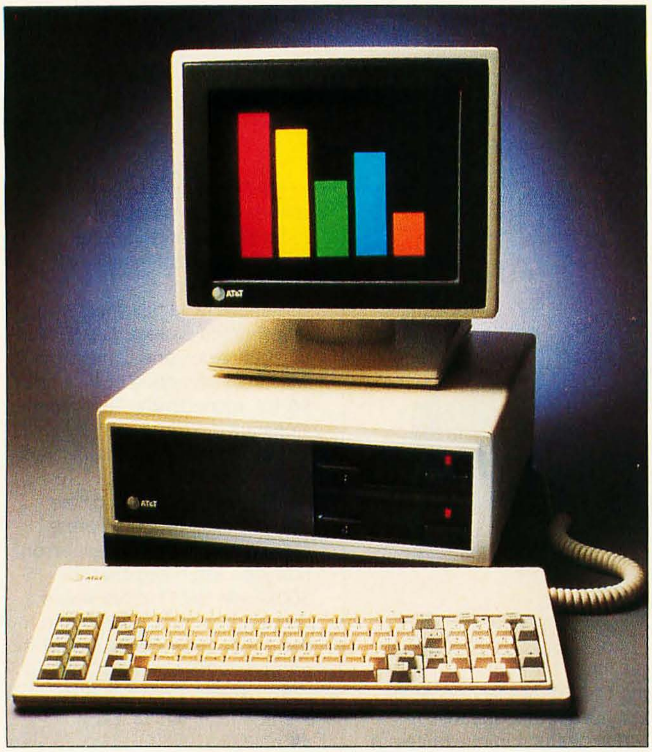
(continued)



AT&T PC Available in Two Versions

The AT&T Personal Computer is available in two models: with dual half-height 360K-byte floppy-disk drives and 128K bytes of RAM or with a single floppy-disk drive, a 10-megabyte hard-disk drive, and 256K bytes of RAM. Both versions can operate in a network with AT&T's UNIX-based 3B computers.

The AT&T Personal Computers are 16-bit machines built around the 8-MHz 8086 microprocessor. They run under Microsoft's MS-DOS operating system, which provides compatibility for a host of business packages designed for the IBM PC. A clock/calendar, backed by a battery, comes standard.

The tilt-and-swivel display produces a PC-DOS-compatible character with a resolution of 640 by 400 pixels. Display resolutions of 320 by 200 are available from both monochrome and color graphics. Proprietary graphics resolutions of 640 by 400 pixels are standard for high-resolution color or monochrome graphics. The screen display format is 80 columns by 25 rows, with an 8- by 16-dot character matrix. Character attributes include reverse, underline, blinking, and high intensity.

Seven expansion slots let you add features to your AT&T Personal Computer. (Six expansion slots are available on the hard-disk machine.) Single RS-232C, Centronics-type parallel, and video display I/O ports are provided. You can expand the RAM to 640K bytes.

Options include a range of 8-bit communications boards, a variety of software, and printers. With DOS, the dual floppy-disk drive AT&T Personal Computer is $2810. The hard-disk model is $4985. For more information, contact AT&T Information Systems, 100 Southgate Parkway, Morristown, NJ 07960.

Circle 602 on inquiry card.

File Manager Manipulates Charts, Words

The CX MacBase from the French firm Controle X is a database manager that lets you manipulate files, text, charts, and graphs. It can process fixed or variable entries along with calculations, charts, tables, graphs, and pictures. Several files can be operated simultaneously. Files can be linked and data exchanged between them.

Using the Mac's mouse, you can draw a model of a document you want on screen, box in titles, position entries, insert a MacPaint diagram or logo, set up tables, and link entries in a matter of moments. The model can be altered at any time. After you create the model, CX MacBase lets you use it over and over again.

You can define calculations, date entries, and set default values. CX MacBase automatically updates files and traces graphs and curve or pie charts. Mathematical calculations include trigonometric, logarithmic, standard deviations, and logical functions.

Hard copy of graphs, reports, labels, and other user-defined forms can be produced. Record information can be sorted on several keys and located by using combinations of criteria.

CX MacBase processes data on a variable-length basis, limited only by the central processor and disk-storage capacities. A file can take up an entire disk; the maximum number of data records depends on their average length, which is usually 1500 to 2000 address records per 400K-byte disk.

CX MacBase will work with MacPaint, MacWrite, and most Macintosh software. It costs $295. Contact Controle X, Tour Maine Montparnasse 33, Avenue du Maine, 75755 Paris, Cedex 15 France; tel: 538 98 87.

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Electronic Mail, Computerized Teleconference System for PC XT

CONEXUS is an integrated electronic-mail, computer-teleconferencing, and bulletin-board system for the IBM PC XT and compatible hard-disk systems.

Written in MIST+, a communications applications language, CONEXUS offers secure private mail, group conferencing, and keyword-accessible bulletin boards for up to 1000 users, each with her or his own ID, password, and access level. Electronic mail is delivered automatically on sign-on, and it can be answered, forwarded, or copied to a conference.

You can trace the status of messages and modify mailed messages before they are received. Other functions include blind and carbon copies, selective delivery, and listing/retrieval of old messages.

CONEXUS's computerized teleconferencing lets several people with a manager-access facility carry on public or private conferences. Members are notified of waiting comments whenever they check in, and status is displayed for all to see. CONEXUS does not limit the number of conferences that can be created.

Users with manager access can institute bulletin boards, which include the ability to search for items by keyword. CONEXUS automatically adjusts to terminal types, giving users complete control over screen width, display pause, full- or half-duplex, and menu status. System operators can modify the CONEXUS code.

CONEXUS requires 256K bytes of RAM and PC- or MS-DOS 2.0. If it is to be accessed via telecommunications, the Hayes Smartmodem 1200, 1200B, or 300 modem is required. It costs $624. Contact New Era Technologies Inc., Suite 924, 2025 Eye St. NW, Washington, DC 20006, (800) 368-5787; in the District of Columbia, (202) 887-5440.

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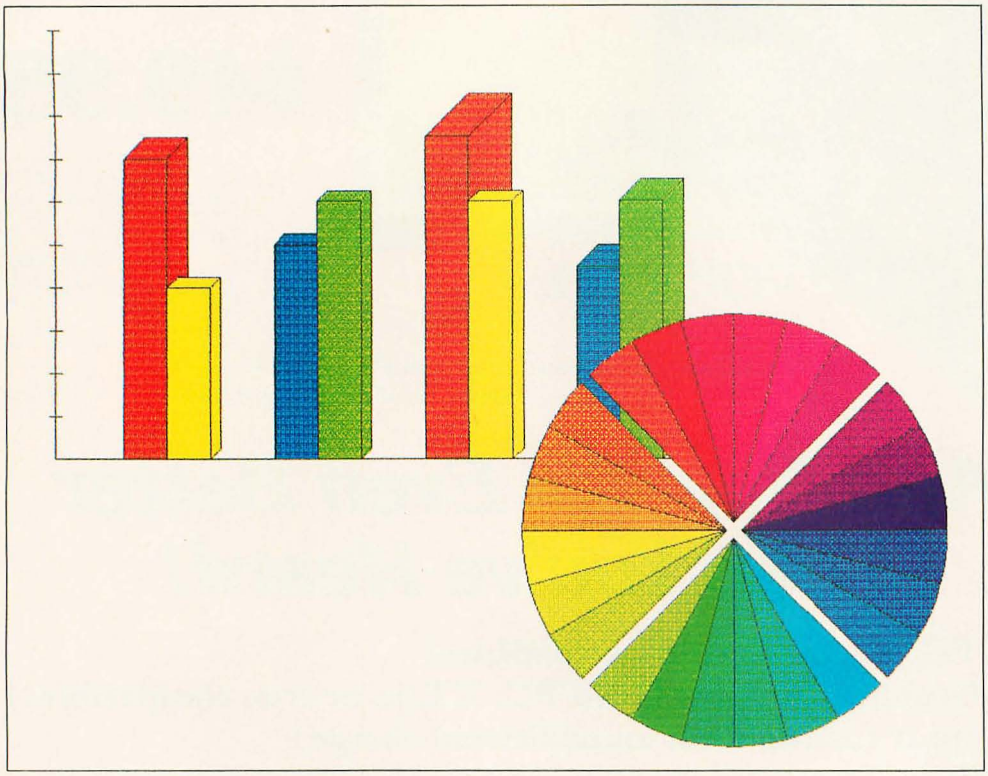

When Lasergraphics' RASCOL Raster Color Image Maker is linked to your computer and a color graphics software package, your raster ink-jet printer can create vibrant color graphics.

A dedicated, microprocessor-based device, RASCOL works by receiving high-level graphics commands from your computer and converting them to color-dot information required by your printer. It assumes image-preparation tasks and printer control, freeing the computer for other work. When not in use, it can serve as a 200,000-character print buffer.

RASCOL drives your printer at full speed with maximum resolution. Printing time is said to be rapid, although dependent on image complexity. The maximum image complexity is typically 60,000 polygon or vector vertices, expandable to 120,000 vertices. Miscellaneous features include the ability to color each object in one of 1 million halftones, scaling and windowing, and arbitrary self-intersecting polygons, pie slices, lines, and text in many fonts.

The RASCOL Raster Color Image Maker makes use of the Lasergraphics Language, which is a graphics communications language that converts graphical objects into color dots for printing. This language is independent of printer resolution and uses 95 ASCII printing commands.

Hardware inputs are serial asynchronous RS-232C ASCII with selectable data rates ranging from 300 to 19,200 bps. The flow control is either hardware DTR or software XON/XOFF. Full- or half-duplex operation is supported.

RASCOL works with Diablo C-150, Xerox 1770, and other color ink-jet prints. It's compatible with Lotus 1-2-3 and other popular software. It works with most personal computers, including the IBM PC. The suggested price is $1995. Contact Lasergraphics Inc., 17671 Cowan Ave., Irvine, CA 92714, (714) 660-9497.

Circle 605 on inquiry card.

Advanced 3270s Have Graphics Functions

IBM's Information Systems Group recently announced two advanced versions of the IBM 3270 Personal Computer for graphics work: the IBM 3270-PC/G and the PC/GX. Both workstations can display charts, diagrams, or drawings in multiple windows and print images on a complementary ink-jet printer using a new control program as well as enhanced programs.

In a simultaneous announcement, IBM introduced a Graphical Data Display Manager (GDDM) and workstation graphics-control software, an optical mouse, a graphics tablet, and an ink-jet printer.

The PC/G's and the PC/GX's graphics processing units receive picture data from a host computer in a so-called "shorthand" vector form. At the workstation, the shorthand data is converted into a full graphics image. Company spokespeople say this reduces by 70 percent the stream of data required to transmit a picture from a host to the workstation.

The GDDM program provides the intelligence to perform this task. It also produces three-dimensional pie charts and bar charts and supports logical input devices. GDDM permits pictures to be interchanged between a GDDM picture library and workstation files. Picture segments can be translated, rotated, and scaled.

The PC/G has an 8-color, 14-inch color display with 720 by 512 user-addressable points. The PC/GX's color or monochrome displays measure 19 inches. Each of its 960 by 1000 user-addressable points can be displayed in up to 16 colors or four shades of gray.

Both workstations can function as stand-alone computers and are built around the IBM 5371 Model 12 system unit, which features 348K bytes of RAM, a 360K-byte floppy-disk drive, and adapters for a parallel printer, mouse/tablet, and for connection to a 3270 system.

The 3852 color printer produces seven-color outputs on special paper and transparencies. An all-points-addressable printer, the 3852 offers 3100 dots-per-second graphics printing and 37 characters-per-second text output. It has two 256-character sets and a pair of presentation modes.

The IBM 5277 Mouse costs $340. The 5083 Tablet Model 2 with a cursor is $900; the price with a stylus is $750. The ink-jet printer is $900. Term leases and installment plans are available through the IBM Credit Corp.

For complete information, contact IBM Corp., Information Systems Group, 900 King St., Rye Brook, NY 10573.

Circle 606 on inquiry card.

(continued)

NEW PRODUCT NEWS FROM TELETEK

Systemaster II. Responding to market demand for speed and increased versatility, Teletek is proud to announce the availability of the next generation in 8-bit technology — the new Systemaster II! The Systemaster II will offer two CPU options, either a Z80B running at 6 MHz or a Z80H running at 8 MHz, 128K of parity checked RAM, two RS232 serial ports with on-board drivers (no paddle boards required), two parallel ports, or optional SCSI or IEEE-488 port. The WD floppy disk controller will *simultaneously* handle 8" and 5¼" drives. A Zilog Z-80 DMA controller will provide instant communications over the bus between master and slave. Add to the DMA capability a true dedicated interrupt controller for both onboard and bus functions, and the result is unprecedented performance. Systemaster II will run under CP/M 3.0 or TurboDOS 1.3, and fully utilize the bank switching features of these operating systems.

SBC 86/87. As the name indicates, Teletek's new 16-bit slave board has an Intel 8086 CPU with an 8087 math co-processor option. This new board will provide either 128K or 512K of parity checked RAM. Two serial ports are provided with individually programmable baud rates. One Centronics-compatible parallel port is provided. When teamed up with Systemaster II under TurboDOS 1.3, this 5MHz or 8MHz multiuser, multi-processing, combination cannot be beat in speed or feature flexibility!

Teletek Z-150 MB. Teletek is the first to offer a RAM expansion board designed specifically for the Z-150/Z-160 from Zenith. The Teletek Z-150 MB is expandable from 64K to 384K. Bring your Z-150 up to its full potential by adding 320K of parity checked RAM (or your IBM PC, Columbia, Compaq, Corona, Eagle, or Seequa to their full potential). The Teletek Z-150 MB optionally provides a game port for use when your portable goes home or a clock/calendar with battery backup!

Evaluate the Systemaster II, SBC 86/87 or Teletek Z-150 MB for 30 days under Teletek's Evaluation Program. A money-back guarantee is provided if not completely satisfied! All Teletek products carry a 3-year warranty.

(Specifications subject to change without notice.)

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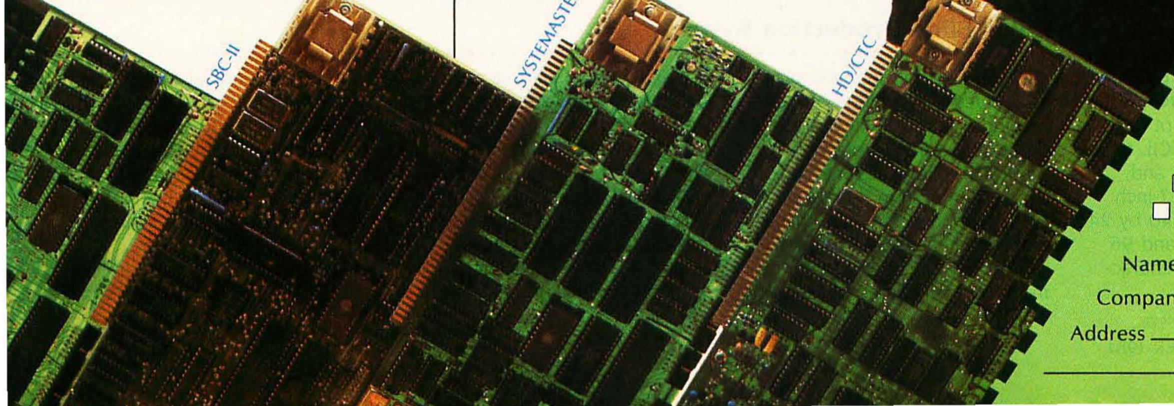

Yes,
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☐ SBC 86/87 ☐ Z-150 MB
☐ Evaluation Program
☐ Teletek's S-100 Board Line

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Color PC Comes with Applications Software

TeleVideo's color version of its IBM PC-compatible computer, the TeleColor PC, Model TS 1605C, comes with word-processing, spreadsheet, and database-management applications software and Microsoft's GW-BASIC. It's built around Intel's 5-MHz 8088 microprocessor and runs under TeleVideo's TeleDOS operating system, which is compatible with MS-DOS 2.11.

The TS 1605C's 12-inch, high-resolution screen tilts. Text characters can be displayed in a single- or double-dot pattern. Monochrome resolution is 640 by 200 pixels; color resolution is 320 by 200 pixels. Sixteen colors are supported, and the display is compatible with many color-graphics applications designed for the IBM PC.

Interface ports supplied are RS-232C serial, parallel printer, and composite video. Mass storage is provided by one or two slim-line 360K-byte floppy-disk drives. System memory includes 256K bytes of RAM, 16K bytes of static video-display RAM, and 8K bytes of EPROM.

The TS 1605C TeleColor PC with a single floppy-disk drive costs $2895; with two floppy drives, it is $3295. A version with a 10-megabyte internal mount hard-disk drive and one floppy drive is $4795. Contact TeleVideo Systems Inc., 1170 Morse Ave., Sunnyvale, CA 94086, (408) 745-7760.

Circle 607 on inquiry card.

Word Processor Runs CP/M, Has Two of Everything

The Bondwell 22, a dedicated word-processing system, serves as your personal computer since it runs under CP/M 3.0. Based on twin Z80A microprocessors, the Bondwell 22 comes with dual CRT displays, two 640K-byte double-sided, double-density disk drives, a 17-cps daisy-wheel printer, and 128K bytes of RAM, 4K bytes of diagnostic ROM, and dedicated memory for the slave processor and video displays.

Shipments are to begin in the first quarter of 1985. At press time, the estimated price is under $3500.

The Bondwell 22's Z80A processors control separate tasks: central and I/O slave processing. This lets you enter and print out data simultaneously.

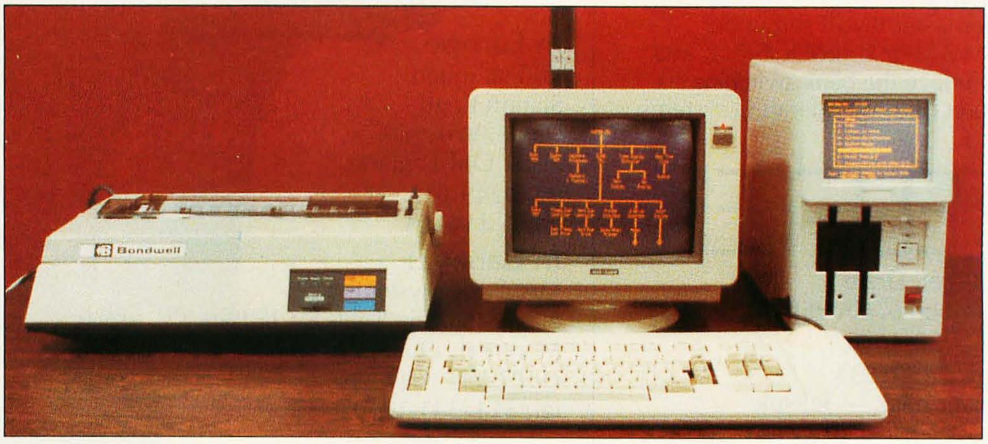
The displays are amber, nonglare CRTs. The larger screen is for text display, while the smaller screen is for the menu. The 12-inch screen includes the following video attributes: 81 by 24 format, underscore, boldface, and soft scrolling. It offers 62 superscript and subscript characters as well as 96 ASCII, 64 graphics, and 228 italic and special characters. The 7-inch auxiliary display has a 40 by 24 format, hard scrolling, and 96 inverse and 64 special characters.

A pair of RS-232C serial ports and a single parallel port are standard. The 56-key keyboard is augmented by 31 programmable function keys and a built-in trackball for cursor control. A real-time clock is also provided.

In addition to CP/M 3.0, the Bondwell 22 comes with a word-processing program and spreadsheet, database, and report-writing application programs. Options include a modem and speaker-phone card and a hard-disk drive.

For full details, contact Bondwell Industrial Co. Inc., Units 10/11, 3300 Seldon Court, Fremont, CA 94539, (415) 490-4300.

Circle 608 on inquiry card.



Color Slide Production System

GraphStation lets you produce color slides of high-resolution bar, pie, line, and other charts in a variety of fonts. This slide presentation/production system, based on an NEC Advanced Personal Computer, comes with an integral optical mouse, built-in color monitor, 256K bytes of memory, 2 megabytes of disk storage, supporting software, and a graphic recording camera. It lists for $6860. A version without the camera is $6155.

Optional equipment includes a communications package that lets the GraphStation accept data from other computer sources. A slide processor/mounter kit and a color plotter are also available. Maintenance, enhancement, and support contracts are available. For further information, contact Signature Information Systems Corp., Suite 300, 8175 Hetz Dr., Cincinnati, OH 45242, (513) 751-1162.

Circle 609 on inquiry card.

(continued on page 468)

The automatic transmission with a $250 differential.

What a way to travel! The Password™ modem is geared to transmit up to 120 characters a second from anywhere to anywhere else in the country at the push of a button. Adjusts automatically to any speed — moving at a high of 1200 baud, or down-shifting all the way to 300 baud.

Totally compatible, it lets any microcomputer phone-communicate with *any* other microcomputer. Easily portable, it parks almost anywhere thanks to the convenience of Velcro™ strips.

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Circle 351 on inquiry card.

You can't buy an IBM® PC with

Here are five important measurements to help you make the best choice:

IBM forces you to choose:

Buy a monochrome card and monitor for high-resolution text. (Essential for word processing and spreadsheets.)

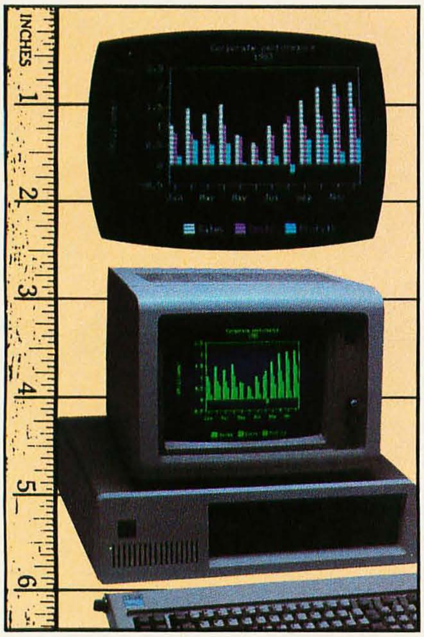
Or buy a color card and color monitor for graphics. (Lotus™ 1-2-3,™ for example, uses lots of graphics, as well as text.)

You can invest in both; you can sacrifice one or the other; you can settle for a non-standard compromise.

Or you can buy Paradise.

Here's how we've measurably eased your job of choosing the best video display (saving you a lot of money in the process).

1. Measure video functions.



The Paradise Modular Graphics Card™ gives you *full screen, 16-shade* graphics on *any* display, including IBM's high-resolution monochrome monitor.

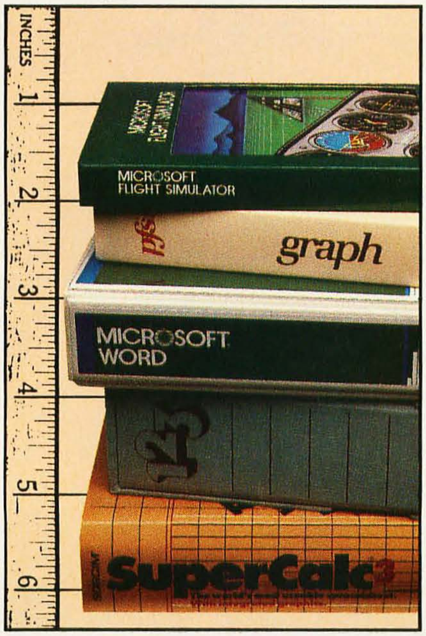
IBM's color/graphics card can display 16 colors on a color monitor.

So can the Paradise Modular Graphics Card.

But that's where the similarity ends. When you use color/graphics software with the Paradise Modular Graphics Card and a monochrome monitor, it translates those colors into a true 16-shade gray scale. With full screen display, flicker-free scrolling and clear, crisp character sets (like those of IBM) in all modes.

Naturally, the best video card fits either the IBM PC *or* XT, and works with any monitor you choose: IBM monochrome (or equivalent), RGB or composite video.

2. Measure software compatibility.



Many video cards only work with specially modified software. The Paradise Modular Graphics Card runs popular off-the-shelf color/graphics software on your choice of monitors. *Unmodified.*

Most cards that offer graphics on a monochrome monitor force you to sacrifice off-the-shelf software compatibility.

Paradise doesn't want you to compromise.

Of course the Paradise Modular Graphics Card runs Lotus 1-2-3 graphics on an IBM monochrome monitor.

But it also runs almost all unmodified off-the-shelf color/graphics software.

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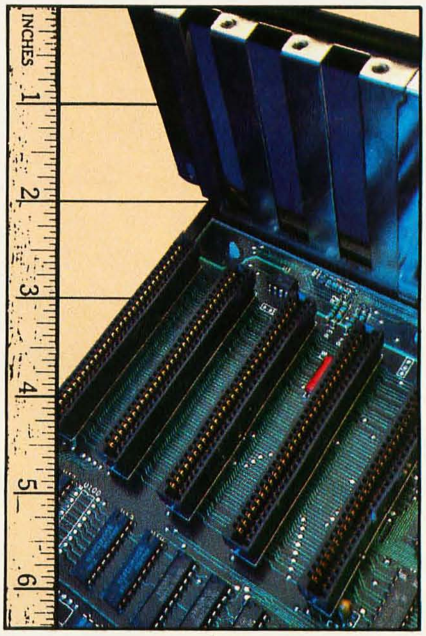
A menu-driven software system—with a user interface much like that of Lotus 1-2-3—lets you take advantage of all the Paradise Modular Graphics Card's features.

3. Measure slot utilization.



Unlike other video cards, the Paradise Modular Graphics Card gives you *additional popular functions in a single slot.* This may be the only card you'll ever need.

You need to worry about slots for future expansion. Since you *must* use

out choosing a video card.

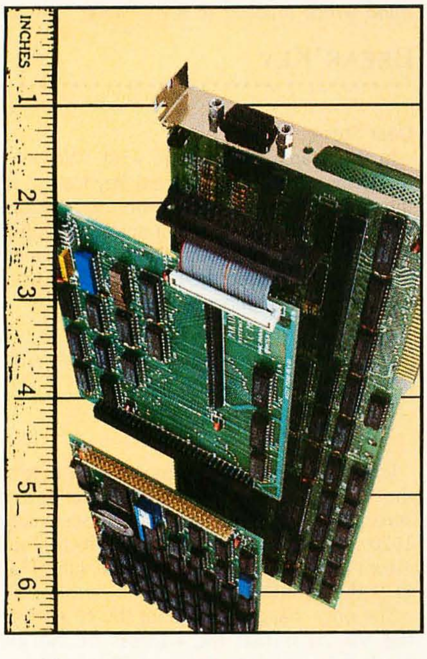
a slot for video support, why not pack it with more functions?

The Paradise Modular Graphics Card puts color and monochrome video support *plus* your choice of the most commonly requested enhancements into one slot.

Enhancements like extra memory, clock calendar, floppy disk controller, parallel, serial or game ports.

Leaving you measurably more room to expand.

4. Measure cost efficiency.

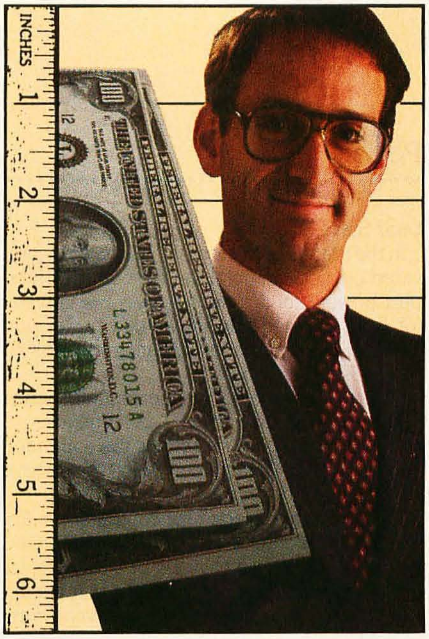


Unlike other multifunction cards, the Paradise Modular Graphics Card lets you choose the options you need, now or later.

You select the features you *want,* when you want them—no more, no less. So you pay only for what you need.

Choose one module from list A, one from list B, or one from each list. The Paradise Modular Graphics Card fits in a single PC *or* XT slot, even with both modules attached. And without imposing on adjacent slots.

5. Measure value.



Value: the ratio of performance to price. No matter how you configure the Paradise Modular Graphics Card, you get more performance for your money, and more performance for your slot.

You'd have to combine several other cards to even approach the Paradise Modular Graphics Card's functionality.

Obviously, that would take up several slots in your PC.

It would also cost you a lot more money.

And if you review measurements one through four in this ad, you'll realize that no other card—or combination of cards—can give you better PC performance.

What about reliability?

Guaranteed by a one year warranty.

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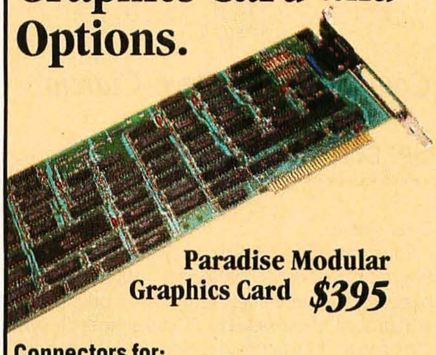

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16K video memory starting at B8000H

Software included:
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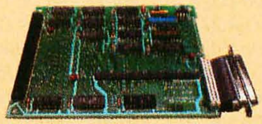
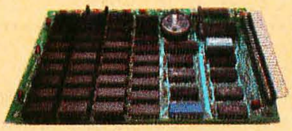
A Module Options:



Parallel printer port *or* • Serial RS232 port *or* • Game port

B Module Options:



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ASK BYTE

Conducted by Steve Ciarcia

SPEECH SYNTHESIS

Dear Steve,

Your article "Build a Third-Generation Phonetic Speech Synthesizer" (March BYTE, page 28) was very interesting. I am working with a Standard Microsystems PC-Talker speech synthesizer, and I want to develop a text-to-speech translation program for it. How can I get a copy of the United States Naval Research Laboratory text-to-speech algorithm?

RODNEY J. ROSS
St. Charles, IL

The NRL algorithm is documented in the research report NRL7948: Automatic Translation of English Text to Phonetics by Letter to Sound Rules *by H. S. Elovitz, R. W. Johnson, A. McHugh, and J. E. Shore. Copies of this 100-page document can be ordered as item AD-AO21929 from the Sales Department, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161. The price for prepaid orders is $13, which includes shipping. Orders are usually filled in two to four weeks.*—Steve

CP/M SOFTWARE

Dear Steve,

The Apple computer with a Z80-based Microsoft Softcard would be a lot more useful if you could read a reasonably standard soft-sectored CP/M 5¼-inch disk (for example, Osborne, Xerox 820, Morrow, etc.) into it. It would also be useful to read disks written on the Apple under CP/M into standard CP/M systems. Why doesn't this work? Do you know any simple way around the problem? Does anyone make a controller that will handle both standard and Apple disk formats? Or is the drive itself strange?

ROBERT J. HANRAHAN
Gainesville, FL

One of the problems with CP/M software is that no "reasonably standard soft-sectored" format exists. Almost every manufacturer has a version that can be read only on its own system. Programs have recently been marketed that will allow one CP/M format to be read by another on a single machine. As you may have guessed, however, they do not handle the Apple-CP/M format.

One of the easiest ways to transfer software between the Apple and another CP/M system is to use the serial ports and some terminal software. A direct connection is fastest, but a modem can also be used to upload and download software as required.—Steve

POWER

Dear Steve,

In the islands of Micronesia, our power is provided by diesel generators. Yap has one of the best power plants here. However, we still suffer from planned and unplanned power outages, power surges, and fluctuating voltage. Our power is U.S. standard.

I have seen ads for uninterruptible power sources, which give you 10 to 20 minutes to store your work and shut down the computer. The costs range from $500 to $1500. Never have so many paid so much for so little.

I would like to operate my computer (an Epson QX-10) continuously from an AC/DC/AC system. Not being an engineer or an electronics whiz, I have this ingenuous notion that I could put one together from mail-order catalog components: Sears Automatic Battery Charger ($70), Sears Deep Cycle Battery (50-100 A) ($90), Sears (Lafayette, etc.) Inverter ($500), and assorted connectors, etc. ($40) for a total of $700.

Is this feasible, or is there some technical problem of which I am not aware? I have a $3000 system, but I shudder at the thought of spending another $1500 to protect it and then being able to run it for only a few minutes. I might be willing, however, to spend $700 for one that theoretically promises trouble-free operation. I know that most power-source advertisers have a vested interest in selling their product and that most people either don't need or want the kind I have described. But I bet there is still a substantial market for this sort of equipment.

Right now, all I have is a $50 surge/spike protector on the line for both the computer and printer. I have had power outages do unnatural things to my disks. Twice they made it impossible to save a file as an indexed file, and I could save the information only by transferring it to another disk as a nonindexed file. A third time, using PeachTree's Mailing List Manager as a database, I lost 60 file cards. A power drop was also responsible for diddling a Valdocs demo disk and inserting Shakespeare quotations in the middle of other text. Yet all I can do now when the power begins to drop is lunge for the Off switch at the back of the unit.

BRIAN FARLEY
Yap, Micronesia

You are definitely not the only person with this type of problem. Quite a few users live in areas where the main source of power is anything but stable.

Your approach is a good one and has been used successfully in the past. One solution was described in the January 1983 "Ask BYTE" (page 481). Richard T. Nicholls used a Tripp Lite power inverter to convert the voltage from a 12-V battery to 110 V AC at 60 Hz. Using this method, he was able to operate his TRS-80 Model I with no problems.

Some inverters put out an alternating voltage that approaches a square wave instead of a sine wave. Some systems will not operate properly with a square-wave voltage. This should be one of the things to look out for when you determine which inverter to use.—Steve.

BREAK KEY

Dear Steve,

In the March BYTE (page 430), Michael J. McCarthy asked about a Break key for use on the VIC-20. I wrote a program for my Commodore 64 that lets it communicate with IBM and Hewlett-Packard mainframes. To implement the Break key, I used the following code upon detecting the F7 function key:

```
1500 BR = (PEEK(56576) AND 251)
1510 POKE 56576, BR
1520 FOR X=1 TO 100 :NEXT I
1530 POKE 56576, BR OR 4
1540 RETURN
```

Line 1500 reads the current output byte to the VIC modem and sets bit 2 (value 4) to a zero. Line 1510 outputs this to the modem. Line 1520 sets the duration. (I found this by trial and error.) Line 1530 turns off the tone. Line 1540 exits the subroutine.

The only change needed for this to work on the VIC-20 is that the address of the VIC modem is probably different. This would require changing 56576 to the proper value.

SCOTT B. REED
Richmond, IN

Thank you for sharing your program. I'm sure many users will welcome this information. —Steve

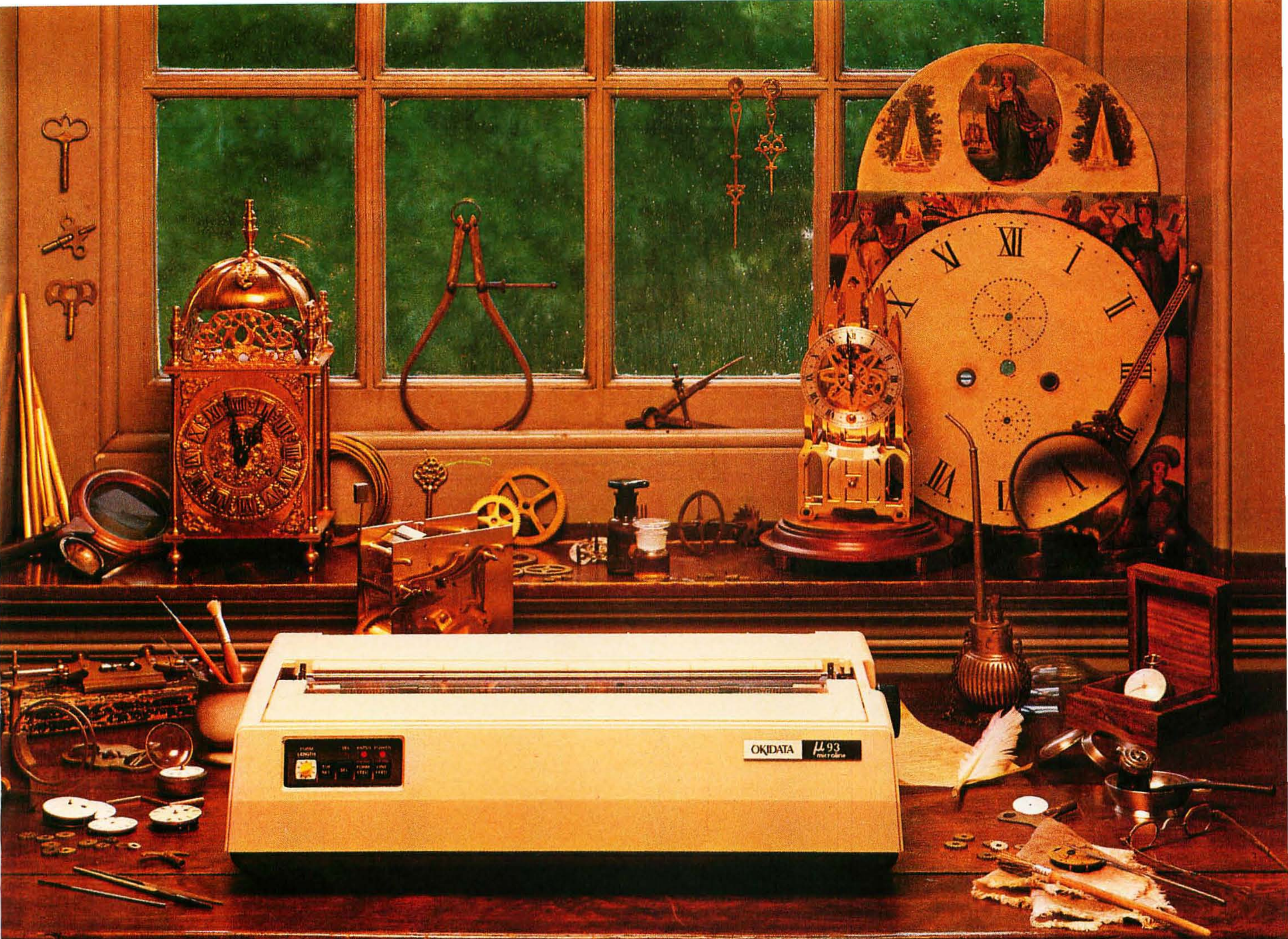
CODE-ACTIVATED SWITCH

Dear Steve,

I greatly enjoy reading your column. Although I do not have an electronics background, I have been able to learn a lot from your articles.

In the May 1983 issue you built the RS-232C code-activated switch. How can I modify this circuit to have a manual switch control the selection of the output channel? I recently purchased a TI-99/4A and anticipate getting an RS-232C interface for it. I would like to be able to switch between a printer and a modem, with a possi-

(continued)



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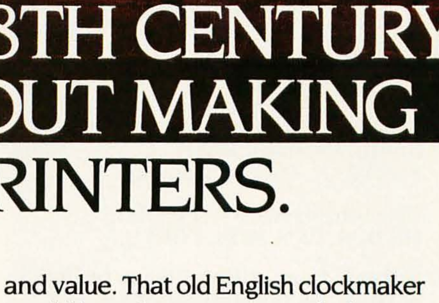

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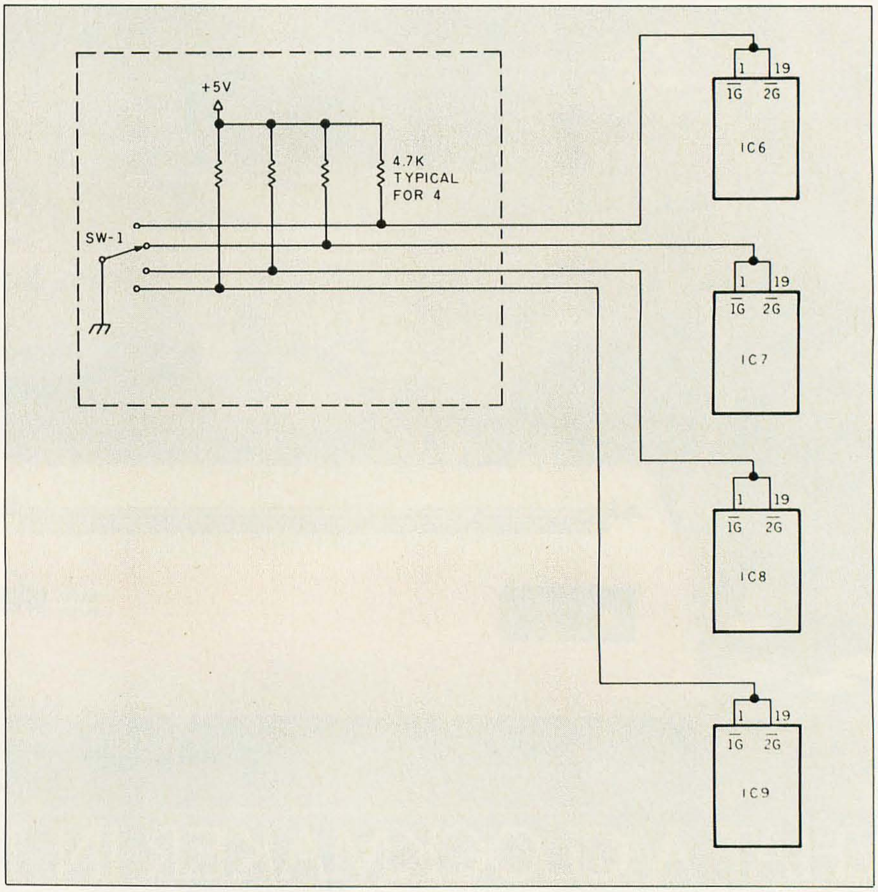

Figure 1: *The new circuit for the manually operated switch. ICs 1, 2, 3, 4, and 5 are replaced by the circuit in the dashed box.*

ble second printer later.

I am also interested in the data bus of the TI-99/4A. Is it possible to attach the RS-232C card for the TI PE Box directly to the computer bus with an appropriate cable if power can be provided for the card? Are you aware of any articles or books that go into detail on the workings of the TI-99?

Dave Peck
Rockford, MI

Converting the RS-232C code-activated switch into a manually activated switch is quite simple because we will be removing many of the original parts. Figure 2 (page 53 of the May 1983 issue) shows the full schematic for the code-activated switch. To convert to a manually operated switch, remove ICs 1, 2, 3, 4, and 5 and replace them with the switch and pull-up resistors shown within the dashed box in figure 1. The rotary switch, SW-1, will now select one of the four RS-232C channels.

The schematics for the TI-99/4A are contained in the TI-99/4A Technical Data Manual. *Write to Texas Instruments Inc., Attn: Dealer Parts Department, POB 53, Lubbock, TX 79408.*

You can also purchase an RS-232C serial port for the TI-99/4A that can be operated without the PE Box. M.W.S. Computers sells one for $149.50. Write to M.W.S. Computers, 22 East Tioga St., Tunkhannock, PA 18657. —Steve

LINE FILTERS

Dear Steve,

Your idea for adding transient protection to a cheap Radio Shack power strip ("Keep Power-Line Pollution Out of Your Computer," December 1983, page 36) could be an excellent way to save money. Unfortunately, I ended up saving money on something else entirely.

I purchased the Archer 61-2620 and three MOVs (metal-oxide varistors) from my local Radio Shack, using the pictures in your article to help locate the necessary components in the busy store. I took it all home and installed the varistors, again using the pictures as a guide. (By the way, the screws on the power strip were a real bear. I had to use a hacksaw to make the heads accessible to a screwdriver.) When everything was finished, I proudly plugged the unit in. Immediately, a flash of light appeared and the unwelcome trail of smoke.

What happened? I took a second look at what I had bought. Instead of MOVs with stock #276-570, I had #276-569s. My varistors were

(continued)

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Circle 224 on inquiry card.

rated at 6 V rather than 120 V! Thus, a minor error translated into an error of 2000 percent in the voltage rating and blew my entire investment.

In retrospect, though, I realize that instead of losing $25 on an incorrectly constructed power strip, I had spent only $25 to learn an extremely valuable lesson: always check the component ratings. Perhaps my story will save your readers this expenditure.

Kenneth Y. Goldberg
Philadelphia, PA

Sorry to hear about your mishap, but your lesson is well learned. Proper attention must be paid to voltage and current ratings of components during design and replacement. In addition to the MOVs, capacitors, transistors, integrated circuits, and diodes can also fall victim to the effects of overvoltage.

A safe procedure for selecting components is to estimate the maximum anticipated voltage and add a safety factor of at least 25 percent.—Steve

Dear Steve,

I have taken apart my Radio Shack/GE spike protectors (pictured on page 42 of your power-line pollution article) and, on the top of them, where the clear plastic part is, inserted two more varistors between the hot, neutral, and ground lines, then soldered them. I extrapolated from your article that having all three varistors on the same circuit like that (as long as you did not cross a wire or solder between leads) would be electrically appropriate. If I am wrong, please let me know.

Donald B. Slaughter
Seattle, WA

Adding the extra MOVs to your spike protector is a tedious but perfectly acceptable method of increasing differential-mode transient protection. I also use such a method for some of my equipment.—Steve

BASIC Protection

Dear Steve,

I would like to know how to disable the LIST command on my Apple IIe so that my program listing cannot be displayed.

Hans Hess
Carmel, CA

A very subtle way exists to disable the LIST command on the Apple II. When listing a program, any statement number that contains a Control-D as the first character of the second line (when listed, not typed in) will execute (yes, execute!) the command immediately following. As an example, type your first program line as follows:

```
10 REM                    PRINT^FP
```

where ^ represents Control-D with no space before FP. (There are 20 spaces after REM.)

Then, when the program is listed, it will clear itself after the first line. Since the REM statement is ignored during running, the program will run normally.

If you are really vicious, replace the FP command with DELETE 'filename'. You can also replace FP with CATALOG to verify that the technique works as described.—Steve

Passwords

Dear Steve,

I am a beginner in the computer field. Where can I get a computer that does not cost a lot and will not perform any tasks without a password? I have been told that some computers will not *run* a program without a password, but all I did was list the program and I got the password. I don't want this to happen to my programs. Can you help me?

Steven Shelton
Wingdale, NY

The best place to put a password requirement for computer access is in the operating system. Any computer that has its operating system on disk, for example, could be modified to require a password before any "ready" prompts were displayed. Examples of such computers are the Apple II and the IBM PC, both of which boot the operating system from a disk and will not run a program on disk until the DOS is loaded.

Placing a password inside a program can be an effective method if the program is in machine language. If your programs are in BASIC, they can be transformed into machine language with the aid of a BASIC compiler. This affords a simple means of protection.

If you must stay in BASIC, there are ways to prevent a program from being listed. This will provide protection against all but the most knowledgeable operators.—Steve ■

IN "ASK BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to

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c/o Steve Ciarcia
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Due to the high volume of inquiries, personal replies cannot be given. All letters and photographs become the property of Steve Ciarcia and cannot be returned. Be sure to include "Ask BYTE" in the address.

The "Ask BYTE" staff includes manager Harve Weiner and researchers Larry Bregoli, Dick Sawyer, and Jeannette Dojan.

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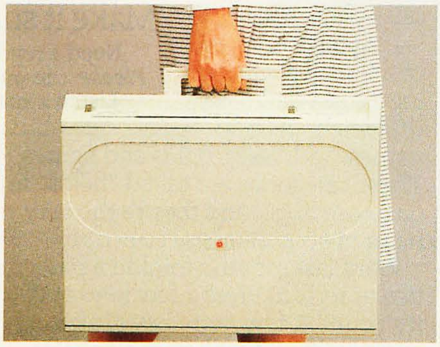

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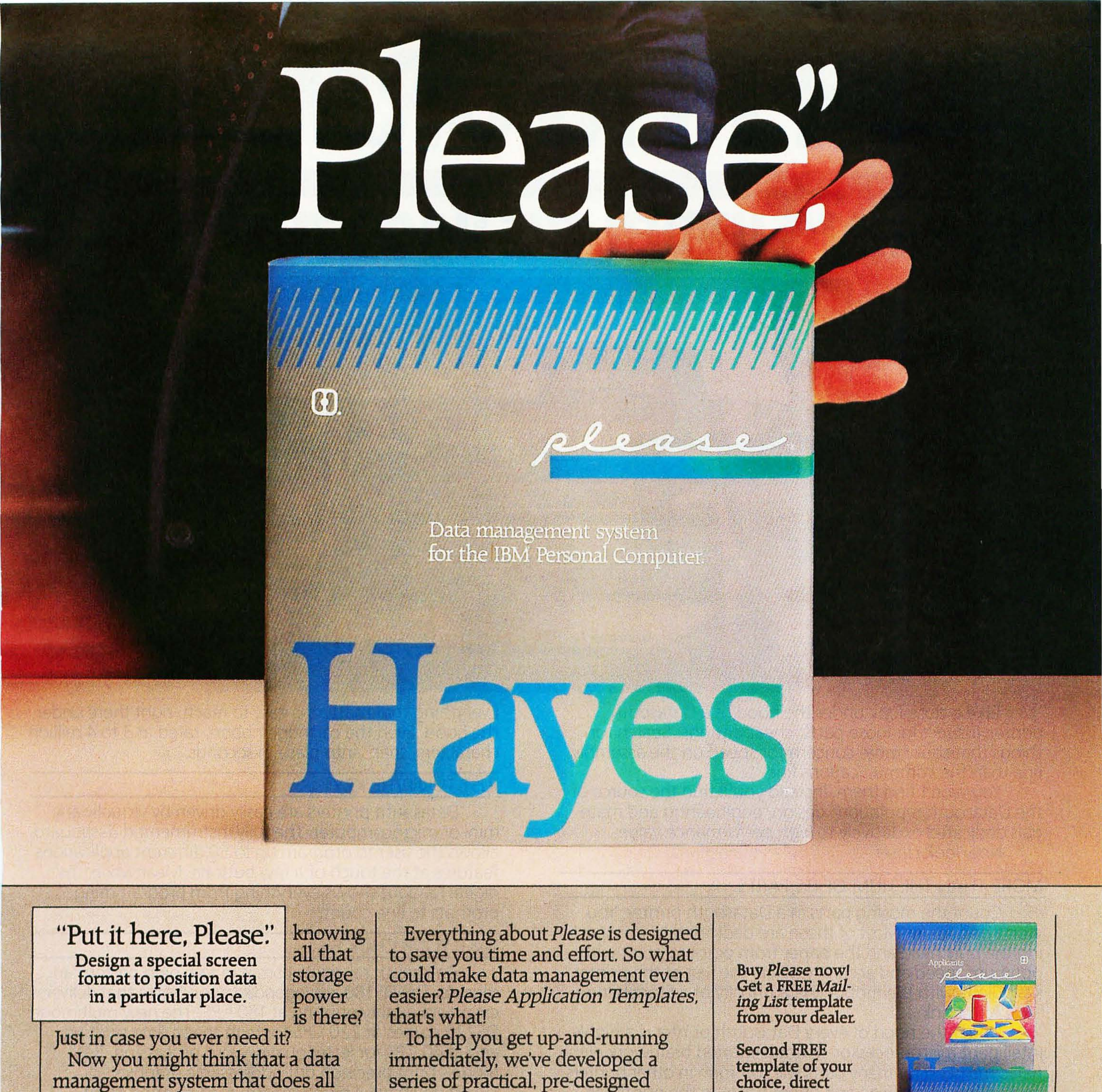
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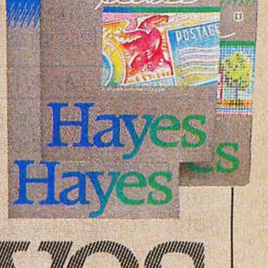
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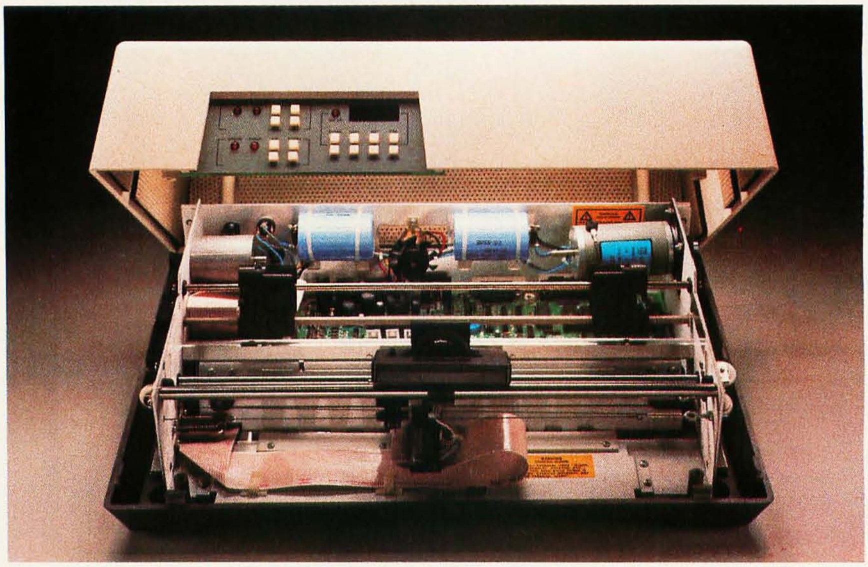

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Now look closer.

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Datasouth design simplicity assures easy maintenance. All control electronics are on a single printed circuit board. The 9 wire printhead is rated at over 500 million characters, and is easily replaced in minutes.

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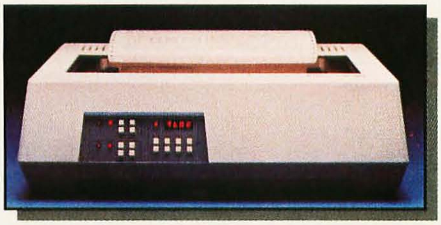

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CLUBS & NEWSLETTERS

● GRAND RAPIDS APPLE GROUP—The Grand Rapids Area Apple Users (G.R.Apple) is an Apple and compatible computers users group serving novice and experienced enthusiasts in the Michigan area with a newsletter, *G.R.Apple News*, and an information exchange. The meetings frequently host guest speakers and software demonstrations, and the possibility of a BBS exists. Membership entitles you to access a library of almost 50 disks and receive the monthly newsletter. Annual dues are $8. Contact Howard Bultman, G.R.Apple, 4444 Bonnie St. SE, Grand Rapids, MI 49508.

● ENGLISH AND KANJI FOR JAPAN—American and foreign owners of NEC computers, particularly the NEC PC-8801A, are welcome to join a users group to share data and programs. A BBS is a possibility. The monthly newsletter will be produced in English; a translation in kanji (Chinese characters) will also be available. The exchange of newsletters or information is particularly welcomed from users or groups in Japan. For details, contact Ryugen C. Fisher, POB 1061, Rhinelander, WI 54501.

● UNITED METHODISTS SPONSOR NETWORK—The Church Computer Users Network (CCUN) is an independent organization of people who promote church uses of computers. The group, organized by United Methodists, welcomes participation from all denominations. Anyone who contributes $15 or more is put on the CCUN mailing list and receives the quarterly newsletter. Members contribute at least $25 a year. For information, contact Clyde McDonald, Church Computer Users Network, 159 Ralph McGill Blvd., Atlanta, GA 30365.

● ARIZONA TI USERS
The TI Newsletter, produced every other month by the Arizona 99 UG, is for owners of Texas Instruments' 99/4A. Information and assistance about programming, architecture, and other topics are contained in the newsletter, a subscription to which is available for $8.95 a year. For details, contact the Arizona 99 UG, 4328 East LaPuente Ave., Phoenix, AZ 85044.

● CP/M USERS HAVE BBS
The Metroplex CP/M Interest Group (MCP/MIG) meets on the third Thursday of every month and welcomes anyone with an interest in microcomputers running CP/M. A BBS is up at (214) 867-2068 and runs at 300 bits per second. A remote CP/M is in the works. The monthly newsletter features articles and announcements that are submitted by members. For further details, contact the MCP/MIG, POB 863909, Plano, TX 75086.

● FOCUS ON NEXUS
Nexus is an independent, bimonthly publication for and by NEC Advanced Personal Computer (APC) users. It contains tutorials, tips, hints, news, and reviews of software and hardware for the NEC APC. Articles include information on telecomputing, modems, conversion tables, adapting peripherals, and more. An annual subscription of six issues is $18 in the U.S., Canada, and Mexico; $30 overseas. For details, contact David B. Suits, 49 Karenlee Dr., Rochester, NY 14618.

● SANYO IN NEW YORK METROPOLITAN AREA—The New York Sanyo Users Group provides technical support to its members by meeting regularly to listen to guest speakers and to hear the latest news about Sanyo products. It maintains a library of public-domain software, a directory of members, and an electronic bulletin-board system. A quarterly newsletter provides for a further exchange of information. Additional information is available from the New York Sanyo Users Group, POB 182, Times Plaza Station, NY 11217, (212) 855-9029.

● COMPUTING IN THE SOUTH OF HOLLAND—The Dutch Computer Club Hobby Computer Club (HCC) meets at 8 p.m. every third Tuesday of the month in the Community Center of Limbrichterveld at Eisenhowerstraat 724 in Sittard. Any readers in the Netherlands of BYTE magazine are welcome to attend the meetings. For details, contact Bert Peters, HCC-Sittard, Via Regia 188-R, 6217 RA Maastricht, the Netherlands.

● FREE NEWS ON IRIS
The originator of the IRIS (interactive real-time information system) operating system, Point 4 Data Corporation, is offering a free IRIS-oriented newsletter. *The IRIS Connection* will include a write-in forum, information on the industry, technical overviews of products, and regular IRIS updates. Article submissions are welcome. For a free subscription, write to *The IRIS Connection*, c/o Point 4 Data Corp., 2569 McCabe Way, Irvine, CA 92714.

● KAYPRO ON LINE
The Kaypro Users Group (KUG), with membership in more than 23 countries, has expanded its bulletin-board system's access by joining CompuServe. Public-domain software and special KUG library programs are available for downloading. Guest speakers are invited to confer on line with all users or you can leave and receive messages. Members access the KUG SIG on CompuServe via GO PCS 25. For starter kits, write to KUG, Box 100, Malverne, NY 11565.

● MESSAGE FROM GEORGIA
The Toccoa Microcomputer Society meets at 7 p.m. on the second and fourth Tuesdays of every month at the Toccoa-Stephens County Library in Toccoa, Georgia. For details, call Steve Shields at (404) 886-9718 or contact Terry Fleming, Rt. 2, Box 124, Eastanollee, GA 30538, (404) 779-3472.

● RADIO IN ON TIMEX
The Timex Sinclair Amateur Radio Users Group (TSARUG) continues to operate despite Timex's absence from the marketplace. Its monthly newsletter for owners of ZX-80, Micro-Ace, ZX-81, and T/S 1000, 1500, and 2068 computers, *QZX*, contains hardware and software reviews, programs and projects submitted by members, and listings of on-air schedules. The annual membership fee is $12, and new members need not be licensed amateurs. Contact Alex F. Burr, K5XY, 2025 O'Donnell Dr., Las Cruces, NM 88001.

● VENEZUELAN PERSONAL COMPUTERISTS—The Personal Computer User's Society meets at 10 a.m. every other Saturday in Barcelona, Venezuela. It supports and promotes the interest, understanding, applications, and research of computing by establishing a communication link between members who own Apples, Epsons, and Color Computers. A monthly newsletter is planned that will include articles written by members and excerpts from magazine articles. For details, contact Osvaldo Briceno, Personal Computer's User's Society, POB 56, Barcelona, Venezuela 6001-A.

(continued)

CLUBS & NEWSLETTERS *is a forum for letting BYTE readers know what is happening in the microcomputing community. Emphasis is given to electronic bulletin-board services, club-sponsored classes, community-help projects, field trips, and other activities outside of routine meetings. Of course, we will continue to list new clubs, their addresses and contact persons, and other information of interest. To list events on schedule, we must receive your information at least four months in advance. Send information to BYTE,* Clubs & Newsletters, *POB 372, Hancock, NH 03449.*

CLUBS & NEWSLETTERS

● CONNECT WITH COMMODORE—The Fairfield County Commodore User Group meets at 7 p.m. on the first Wednesday of the month at Hatter's Park in Danbury, Connecticut. Its objective is to promote the use of Commodore 64 and VIC-20 computers. A newsletter, *Bits & Bytes*, contains member-written software reviews, programming tips, and upcoming activities. The $12 annual membership fee includes the newsletter and access to a BBS in the works. For details, contact Kenneth Hottes, Fairfield County Commodore User Group, POB 212, Danbury, CT 06810.

● USERS PLOT PLANS
A nationwide GRiD Users Group provides members with access to a nationwide electronic newsletter, *GRiDNeWS*, and an information-sharing system designed for GRiD users. Subscribers can benefit from electronic mail, product announcements, a technical column, questions and answers, articles, and hints. It is sponsored by Business Computing International Incorporated of New York City. For further details, contact Richard Horan, *GRiDNeWS*, c/o Business Computing International, 342 Madison Ave., New York, NY 10173, (800) 522-BCII.

● MICRO-5 FOR TEACHERS
Micro-5 is the first microcomputer users group for educators in North Carolina. It sponsors conferences with special-interest sessions, guest speakers, and small groups for specialized topics. Various computers will be displayed, and hands-on experience is available. Demonstrations include network implementation. For details, write to Micro-5, Rt. 2, Box 204, Ramseur, NC 27316.

● MEET MAC IN BOSTON
The Macintosh Users Group, a recent special-interest group in the Boston Computer Society (BCS), is designed for both novice and technical people. It meets at 7 p.m. on the second Wednesday of every month in the Tower Auditorium of the Massachusetts College of Art (621 Huntington Ave., Boston, MA) to witness demonstrations and presentations and to discuss software, peripherals, and the uses of the Macintosh. The group plans to produce a newsletter and create a software library. Each member receives a subscription to the BCS monthly magazine, *Computer Update*, and can attend general BCS meetings. For further details, contact Jack Hodgson, BCS, Macintosh Users Group, One Center Plaza, Boston, MA 02108, (617) 367-8080.

● NETTING CP/M USERS
For users of Kaypro, Morrow Designs, Osborne, Xerox 820, and Big Board, the CP/M Users Net meets on the air every Sunday night at 9 p.m. (0300 GMT) on the frequency of 3.968 megahertz (MHz). Members of the net find and exchange public-domain software that is CP/M 2.xx-compatible to run CW, RTTY, AMATRON, ASCII, RCP/M, BBS, and others. The only dues are an amateur license and suitable interest. For net control, contact K5DHZ Bud; for alternate net control, contact WB6UTY Barry; and for the net database manager, contact AG0N Gary.

● SINCLAIR QL USERS IN UNITED KINGDOM—
Membership in the Independent QL Users Group (IQLUG) is available by subscription to the monthly newsletter, *Quanta*. The group also maintains a free software library, provides a free advice service, conducts workshops, and offers support for local groups. A six-month trial subscription is $4.25. Group interests include business, amateur radio, database, graphics, education, communication, and languages. For details, contact Brian Pain, 24 Oxford St., Stony Stratford, Milton Keynes, MK11 1JU, U.K.; tel.: (0908) 564271.

● APPLICABLE TO ENGINEERS
The *Engineers Computer Applications Newsletter* (*ECAN*) is a monthly newsletter for practicing engineers that provides information, analysis, and guidance on the applications of small computers. Contents include a software exchange, hardware notes, a graphics update, publication reviews, and a calendar of related events. Subscriptions are $96 per year; $120 a year overseas. For details, contact Engineering Computer Applications Inc., POB 3109, Englewood, CO 80155-3109, (303) 797-3603 ■.

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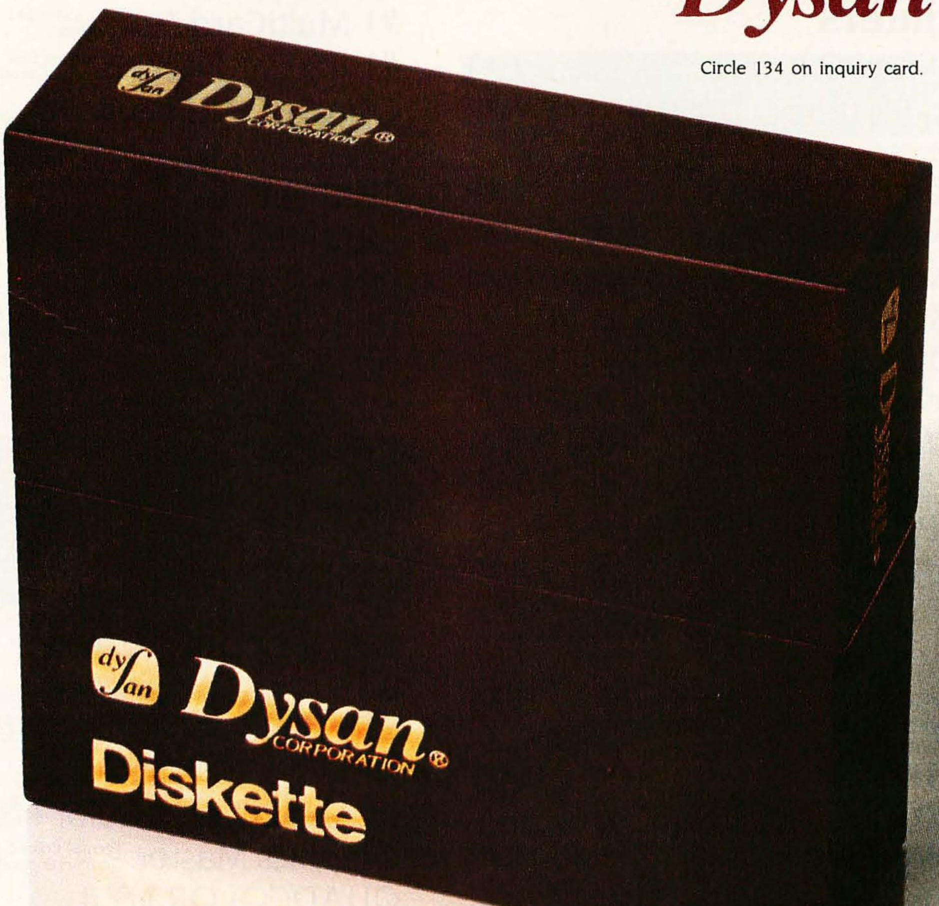

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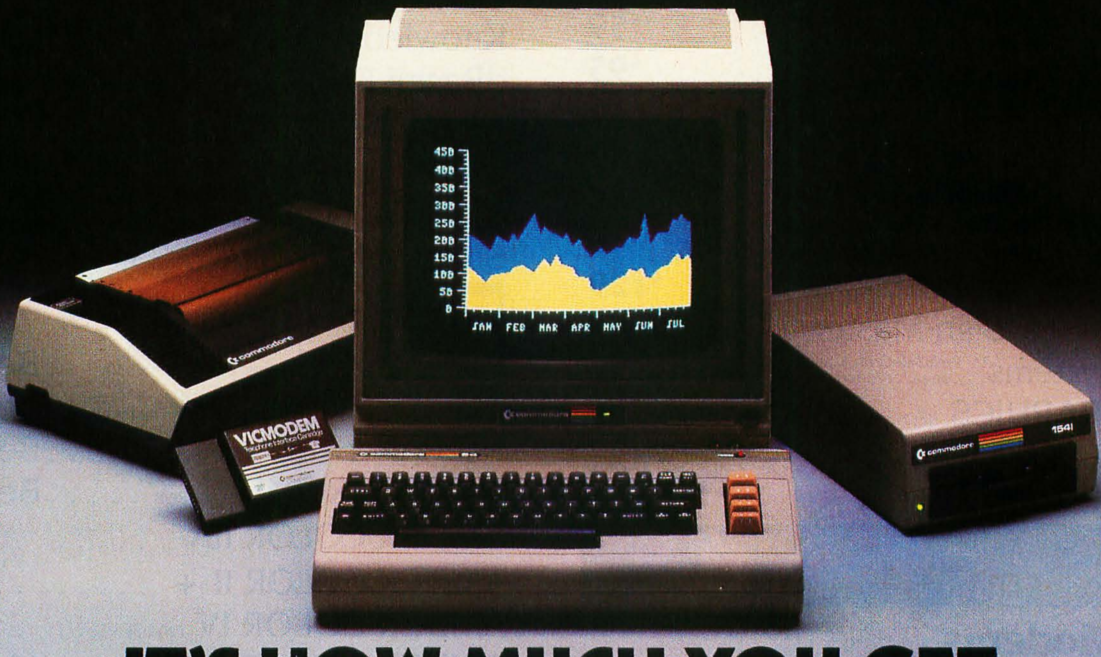

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BOOK REVIEWS

THE DOCTOR'S
COMPUTER HANDBOOK
Peter J. Fell and
William D. Skees
Lifetime Learning Publications
Belmont, CA: 1984
270 pages, $27.50

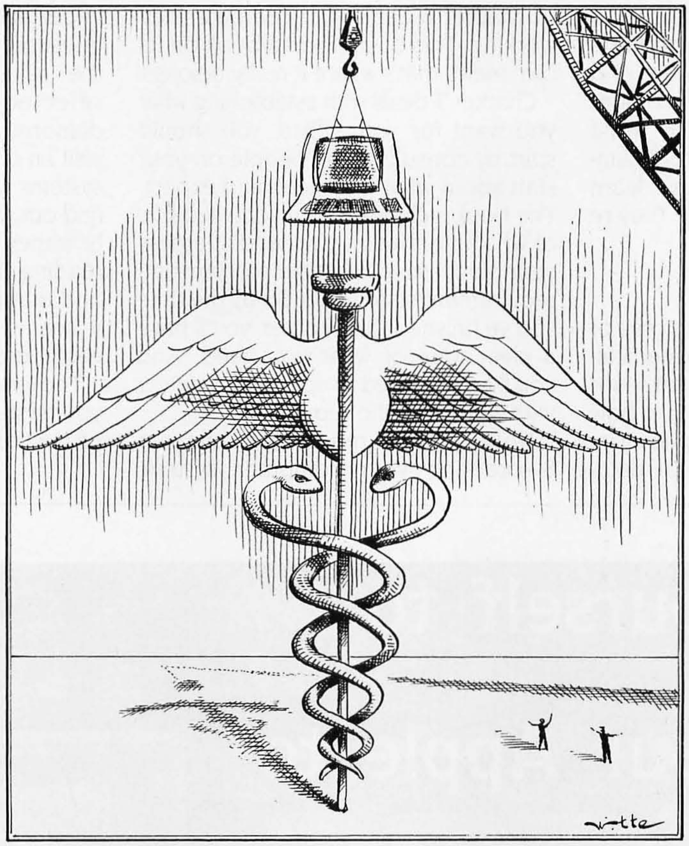
APPLIED CONCEPTS IN
MICROCOMPUTER GRAPHICS
Bruce A. Artwick
Prentice-Hall
Englewood Cliffs, NJ: 1984
384 pages, $29.95

AUTOMATING YOUR
FINANCIAL PORTFOLIO
Donald Woodwell
Dow Jones-Irwin
Homewood, IL: 1983
251 pages, $19.95

ART AND GRAPHICS
ON THE APPLE II/IIe
William H. DeWitt
John Wiley & Sons
New York: 1984
128 pages, $14.95

THE DOCTOR'S COMPUTER HANDBOOK

Reviewed by Bruce R. Evans



The Doctor's Computer Handbook is a gem. It leads you through the pitfalls of computerizing a medical practice in a style that should be a model for all technical writing. Although it was written for doctors planning to computerize their offices, it should be read by anyone interested in business computing.

The authors are an interesting pair. Peter J. Fell is an English general practitioner who has successfully computerized his medical practice. Considering the stringency of the British medical system, this is quite an achievement. William D. Skees is an American computer scientist with a strong practical background in databases and computer networking. Both these areas are dealt with exhaustively in this book. (In fact, networking is overdone in my opinion.) This coauthorship overcomes the problem inherent in most books on medical computing—few doctors are computer experts, fewer computer experts know medical practice. Fell and Skees complement each other well.

DUALITY

The Doctor's Computer Handbook is in two parts. The first, which is the bulk of the book, explains how to set up a computer system in a medical office. The authors begin with the assumption that a computer is a necessary part of medical practice; then they convince you. The second portion is an overview of computer use in a hospital and laboratory. This second part is smaller and almost superfluous.

As the authors assume the reader knows nothing about computers, they start by explaining what a computer can do for a physician's practice. For convenience, they break the uses for a computer into two parts. First there are those that are peculiar to a physician's office—medical records, patient instruction, and medical research. They give some ideas of what a computer can and can't do. Then they go on to discuss the uses that exist in all small businesses. These are the accounting functions—accounts receivable, accounts payable, general ledger, and payroll.

Although I agree with all that the authors say in this chapter, I disagree with their emphasis. In North American practice, the accounting functions of a computer pay the freight. The other functions are bonuses. I completely disagree with the emphasis on computerized medical-record keeping. Fell and Skees do give examples of standardized medical forms, but these are too limiting by North American standards. A pen and paper are still the best instruments for keeping medical records—quick sketches don't fit into a computerized record. However, most of us would benefit by incorporating some of their ideas into our standard medical histories.

Chapters 2 and 3 come right to the point. Can my present system be converted holus-bolus or will I have to make a lot of changes? What will computerization of my medical practice cost? The first question is dealt with thoughtfully and completely. The second isn't. In chapter 2, the authors get all wrapped up in pseudomathematical formulas for calculating costs, benefits, and break-even points of computerization. It doesn't work. Their precise formulas are

(continued)

ILLUSTRATION BY MICHAEL WITTE

The four-page summary of all hardware systems and their statistics resembles a racing form.

really rough estimates in disguise.

Chapters 4 and 5 educate the computer novice about the hardware and software involved in computerization; thus, average readers of BYTE won't learn anything here. Most doctors planning to computerize, however, will learn a lot from these two chapters. They're well done.

THE REAL THING

Chapters 6 and 7 are the high notes of this book. Chapter 6 goes into medical-applications programs. First you learn what a menu-driven program is and how it will apply to a particular application. The chapter describes medical databases and word-processing packages. Each of these is discussed with specific examples. The authors point out how to assess program strengths and weaknesses so you can decide whether what's available to you is suitable. Unfortunately, I once again disagree with the authors' emphasis. Almost a third of chapter 6 deals with computer networking. This could form a book on its own merit; that's where it really belongs.

Chapter 7 deals with establishing what you want for your office. You should start by consulting the people on your staff about what they need and expect. The book includes helpful, detailed lists of what information you need to assess your purchase and sample problem and requirement statements. So by the time you've finished this chapter, you'll have a clear idea of what you need. And you'll be prepared to approach a dealer with your specific requirements.

Now you're ready for chapter 8—ordering your computer system. Again, the authors provide numerous practical lessons: examples of requests for quotations (RGQs), computer leases, and lists of manufacturers. A terrific four-page summary of all hardware systems available and their basic statistics resembles a racing form for computers. Fell and Skees stress how important it is to test the systems in question with your own raw data, not the salesman's files that are often selected for speedy, error-free demonstrations. You are encouraged to visit an office that's actually running the systems you're interested in. You can find out what problems they've had and how they solved them. When I finished reading this chapter, I was amazed to find that it's the shortest in the book—it seems to contain endless down-to-earth, practical examples.

The end of the last part addresses your system after installation. Examples of maintenance schedules and checks

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e and local aid,
And the right
es. What can
deficits?
Plenty.

are excellent. The authors discuss adding new programs to your system: should you write them, modify them, or just buy them off the shelf? These last chapters are required reading for anyone who uses a business computer in any capacity.

The end of the book about institutional computing is anticlimactic. Here you'll learn about Computerized Axial Tomography (CAT scans) and other equipment. Although it's interesting, it's not as useful as the beginning of the book.

UNLIMITED

I can't finish this review without adding a comment on its style of technical writing. Simply, it's in a class of its own. Each chapter is written concisely and has a common format. First the authors tell you what's in the chapter. Then they give you the information accompanied by many charts, examples, and lists. Finally, they summarize it. Unity, clarity, and coherence are some rules of thumb not found elsewhere.

In summary, this well-written book fulfills its promise of showing a physician how to computerize the office. The advantages, disadvantages, and pitfalls are all discussed, as well as scads of timely tips. However, in recommending this book, I wouldn't limit it's usefulness only to physicians. If you have any ambition of writing medical programs or if you plan to sell medical systems, you'll find this book a worthwhile addition to your library.

APPLIED CONCEPTS IN MICROCOMPUTER GRAPHICS

Reviewed by Jeff Campbell

Many of us think of computer graphics in terms of CAD/CAM (computer-aided design/computer-aided manufacturing) systems, or perhaps of some sort of Pac-Maniac glibly munching power dots. What we may tend to take for granted is that those little characters that appear on our display screens actually represent computer graphics at its most basic. They form the basis for virtually all human–computer interaction and enable us to verify instructions properly given and received. Bruce A. Artwick's book, *Applied Concepts in Microcomputer Graphics,* will interest those with a cursory interest in this vital field and should be required reading for people considering customized graphic applications for their microcomputers.

PRELIMINARIES

Artwick begins his far-ranging treatise with an overview of today's state-of-the-art graphics. He then discusses the equipment available in the marketplace, with attention to its advantages and disadvantages in differing applications. Throughout the book, Artwick focuses on efficiency in terms of cost-effectiveness and computational time.

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Chapter 2 introduces the reader to the basic software concepts of computer graphics: the various coordinate systems and methods of plotting to those coordinates. In computer graphics of any kind, one inevitably starts out by plotting two points in two-dimensional space and connecting them with a line. Once done, the next obvious consideration is how to best display the results to the user, and this is covered in a chapter on display-generation hardware. We are reminded that the LEDs (light-emitting diodes) and LCDs (liquid-crystal displays) on our portable calculators and digital watches are as integral to the display arena as the more glamorous RGB (red-green-blue) monitors. A survey of peripheral graphic devices is included: the joysticks, trackballs, light pens, and digitizing tables that allow the user to bypass the often cumbersome process of keyboard entry and, in the same vein, the various printers and plotters that permit hard-copy output.

A RELEVANT TOOL

The remaining chapters are more specialized, delving into the practical applications involved in submitting various design elements (lines, rectangles, circles, ellipses, and other symbols) and working interactively with the computer system. The less technically oriented user may well be intimidated by some of the concepts involved, particularly when the author moves into the transforms and mathematics required in advanced graphic operations of scaling, zooming, three-dimensional rotation, and so on. A lot of information is contained here, and even if one is unable to appreciate the mathematics involved, the book still serves as a valuable reference tool.

Chapter 8 introduces the reader to the literally fast-moving realm of high-performance graphics and animation, detailing the speed-up techniques and hardware/software performance boosters that, in many cases, allow computer animation to equal and even surpass conventional animation techniques.

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achieve the capability of high-quality simulations. Simulations allow for less stressful learning conditions. Obviously, any errors made in the navigation of a spacecraft or massive supertanker could have catastrophic results. The author explores different simulation possibilities, including recent systems that permit the training of personnel in nuclear-power facilities.

A chapter on business graphics concludes the book. Business graphics could supply material for several books alone, as indeed it does, but Artwick supplies us with a broad overview that encompasses not only standard pie charts and graphics but also considers report and presentation graphics, typesetting, photographic-image handling in advertising, and the trend towards total office automation. Special appendixes for graphics on the Apple II and IBM Personal Computer are included.

Artwick offers us a straightforward look at the interesting and indispensable field of computer graphics. This book contains many relevant illustrations, examples, and sample programs. In short, it is a wealth of practical information and a helpful reference work.

AUTOMATING YOUR FINANCIAL PORTFOLIO

Reviewed by Paul Ross

Although there are quite a few ways to invest your money, active investment programs require frequent analyses of vast quantities of data. For example, fundamental stock analysts search for stock issues that are underpriced considering the business prospects and assets of the issuer. This process involves detailed analyses of debt-equity ratios, cash flow, market dominance, undervalued real estate, predicted growth rates, management quality, and many other factors. On the other hand, technical stock analysts look for trends and cycles in stock prices and volumes that reveal public sentiment and foretell stock-price changes. Option analysts usually calculate the fair price of options—a quantity that depends on the price and historic volatility of the stock underlying the option, among other things. Bond analysts need to compare the current yield and yield to maturity of various issues and take into account the risk of default by the issuing agency.

In short, investment analysts have different, and sometimes incompatible, philosophies of what constitutes real worth. But all investors share the belief that if they could just analyze more data their investment programs would be more profitable. It is not surprising that investors are enthusiastically adopting personal computers.

AUDIENCE

Automating Your Financial Portfolio, by Donald Woodwell, surveys the use of

(continued)

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PRINTERS

MICROPRISM	110 cps, 84×84, graphic	**379**
DATA PRODUCT	8000 series	**CALL**
EPSON	FX-80, FX-100, RX-80, RX-100	**CALL**
BANANA	50 cps	**195**
OKIDATA	Full Line	**CALL**
PRISM 132	200 cps, 132 col	**1,100**
TOSHIBA	192 cps 24-wire	**1,450**
DEC	LA50	**599**
GEMINI	Delta 15	**559**
DIABLO	P11 100 cps, 80 col.	**488**
	P38 400 cps, 132 col	**1,795**
M.T.	Spirit 80 cps	**345**
	Letter Quality	
NEC	2050 20 cps for IBM	**840**
	3550 35 cps for IBM	**1,610**
	7710 55 cps for serial	**1,750**
DYNAX	HR25 23 cps parallel	**735**
	DX15 13 cps parallel	**445**
COMREX	Comwriter III	**740**
C.ITOH	F-10 40 cps Excellent	**999**
	A-10 18 cps	**530**
DIABLO	630 API w/interface	**1,735**
QUME	11+ 40 cps	**1,300**
	50 cps	**1,500**
JUKI	6100 parallel	**459**
STAR	Power Type 18 cps	**379**
TRANSTAR	315 graphic	**479**

MODEMS

HAYES	Smartmodem 300/1200 bps	**499**
	Micromodem II w/software	**270**
NOVATION	Smartmodem 300/1200 bps	**415**
	PC Cat 300/1200 bps	**450**
USR	Password 300/1200	**339**

Anchor Automation, Anderson Jacobson
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ZENITH ZT-1, ZT-11 with modem .....Call

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TECMAR, QUADRAM, HERCULES

POWERFUL 68000 CPU

Cromemco	68000/Z80 CPU
option	Fast Floating Point Processor
DUAL	68000 CPU, 80MB SMD hard disk, intelligent I/O, UNIX, Database
WICAT	1 to 12 users, 68000 CPU, 256K to 4.5MB RAM, 10MB to 474MB hard disk, graphic

DEC VT-100 Compatible Terminals

DEC	VT100AA	**1,600**
	VT220A	**1,050**
QUME	103	**780**
Visual	102 14"	**890**
(option)	graphic	**695**
WYSE	75	**675**
ZENITH	Z-49	**CALL**

PLOTTERS/DIGITIZERS

HOUSTON INSTRUMENT	DMP 29	**1,795**
	DMP 40	**795**
	DMP 41, DMP 42	**CALL**
	HIPAD digitizer	**725**
AMDEK	XY plotter 1 pen	**620**
	6 pens	**895**
M.T.	PIXY-3 3 pens	**650**
HEWLETT PACKARD Plotters		
	7470A 2 pens	**940**
	7475A 6 pens	**1,640**
SWEET-P	100 w/support pack	**625**
GTCO digitizer		**CALL**

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ZENITH	Z-29 smart terminal	**BEST PRICE**
ZVM 135	RGB color/green monitor	**475**
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ZVM 124	22 MHZ, for IBM	**169**
Amber Monitor: Comrex, Panasonic, Zenith		
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	HX-12	**490**
	SR-12	**630**
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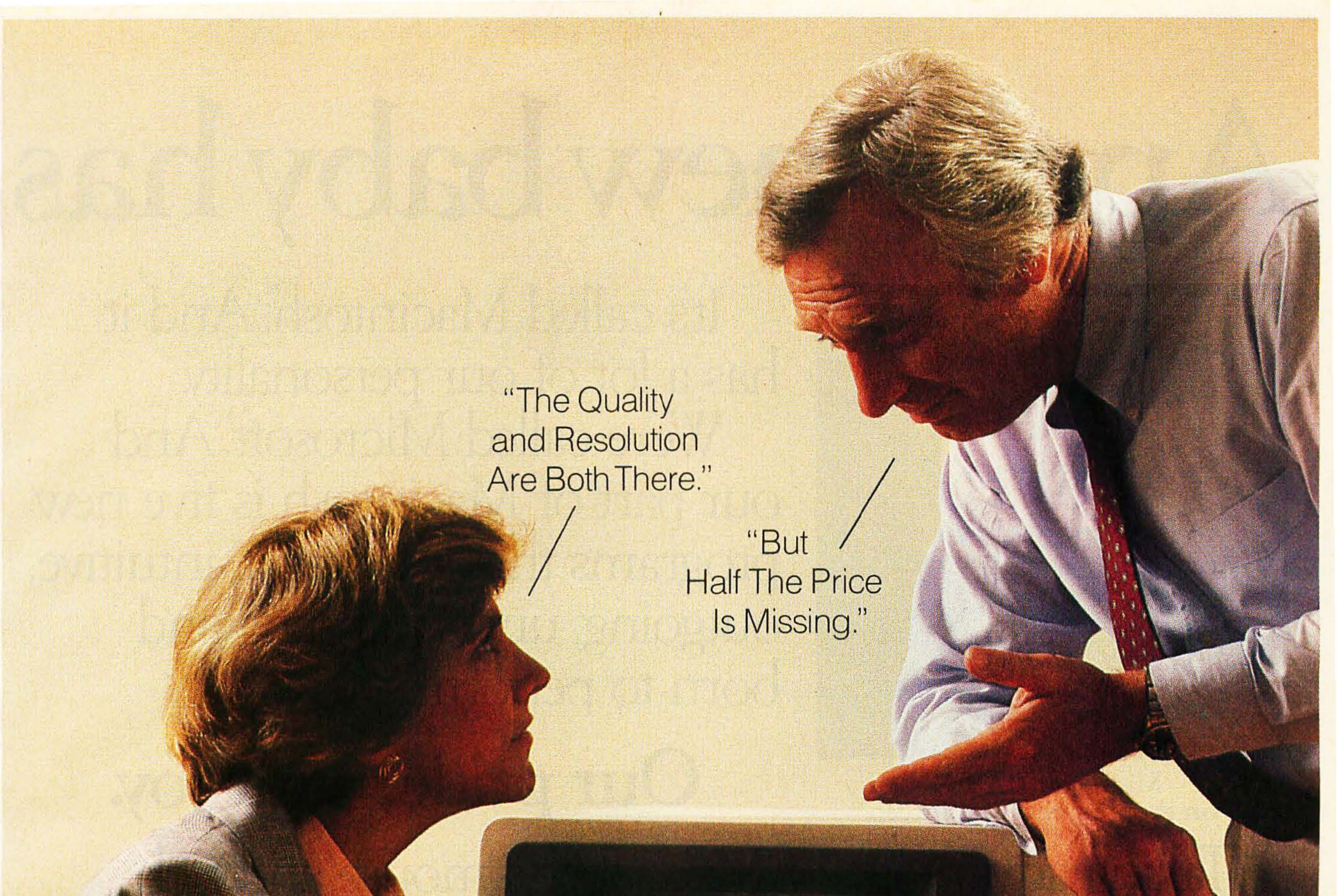

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And both terminals come with a wide variety of advanced graphics features. Resident vector draw. Point plot. Circle and arc draw. Rectangle draw. Multiple line styles and patterns with rectangle pattern fill. Plus an auxiliary port to support printer/plotters and data tablets.

As an alphanumeric terminal, the VISUAL 500 provides selectable emulations of the DEC VT52,® Data General D200, Lear Siegler ADM-3A™ and Hazeltine 1500 terminals. While the VISUAL 550 is DEC VT100® protocol-compatible as well as a character or block mode terminal which complies to the ANSI X3.64 standard.

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Apple's® new baby has

```
150 IF MOUSE(0)=0 THEN 150
160 IF ABS(X-MOUSE(1))>5 GOTO 180
170 IF ABS(Y-MOUSE(2)) < 6 THEN 15
180 PUT(X,Y),A
190 X=MOUSE(1) Y=MOUSE(2)
200 PUT(X,Y),A
210 GOTO 150
220 CLS
230 LINE(0,0)-(120,120),BF
240 ASPECT#=1
250 WHILE ASPECT#<20
260   CIRCLE(60,60),50,30,,ASPECT#
270   ASPECT#=ASPECT#*1.4
280 WEND
```

```
150 IF MOUSE(0)=0 THEN 150
```

Microsoft BASIC
on Apple's new Macintosh

It's called Macintosh.™ And it has a lot of our personality.

We're called Microsoft.® And our part of Macintosh is five new programs that are bright, intuitive, outgoing, understanding and born to perform.

Our pride, your joy.

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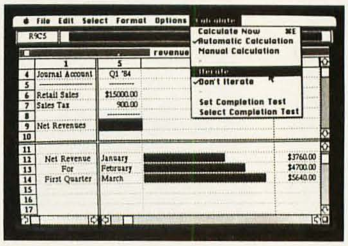
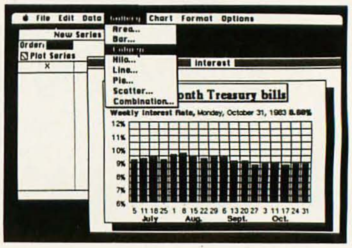


	1	5	
4	Journal Account	Q1 '84	
5			
6	Retail Sales	$15000.00	
7	Sales Tax	900.00	
8			
9	Net Revenues		
10			
11			
12	Net Revenue	January	$3760.00
13	For	February	$4700.00
14	First Quarter	March	$5640.00
15			
16			
17			

Microsoft Multiplan



Microsoft Chart

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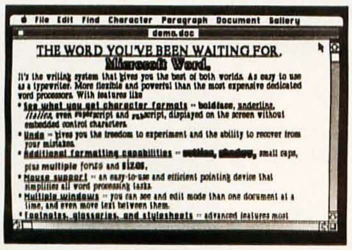
And BASIC, the language spoken by nine out of ten microcomputers worldwide, is the granddaddy of them all.



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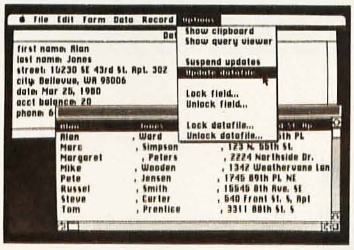
Microsoft Word



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last name: Jones
street: 10230 SE 43rd St. Apt. 302
city: Bellevue, WA 98006
date: Mar 26, 1980
acct balance: 20
phone: 6

Alan , Ward
Marc , Simpson , 123 N. 66th St.
Margaret , Peters , 2224 Northside Dr.
Mike , Wooden , 1342 Weathervane Lan
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[1] *Photo display using PC with color monitor and color/graphics interface card.*

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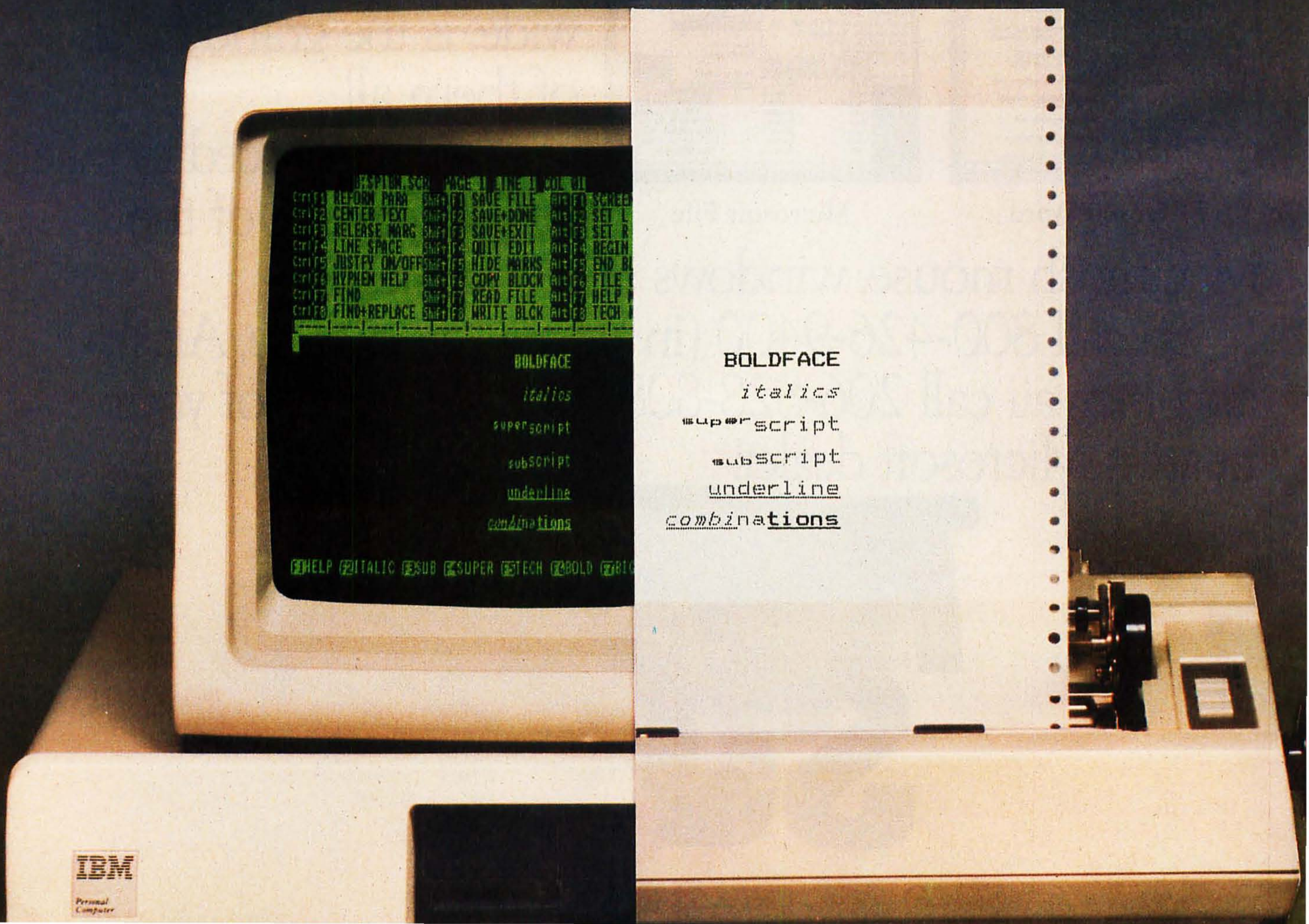


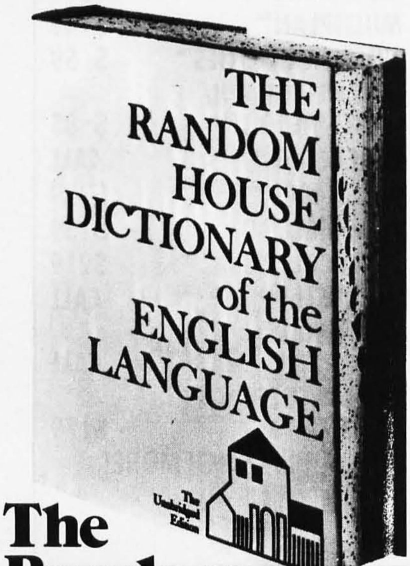
personal computers as an investment aid. One great strength of this book is that it contains sample outputs from different financial programs from which a knowledgeable investor can glean programs that produce the exact information required. Experienced investors will find *Automating Your Financial Portfolio* useful as an introduction to functions in available programs. Combine this book with a few technical brochures from vendors listed in the book, and an experienced investor could choose a suitable computer and program to automate a substantial amount of the routine work in an established investment program. Thus, stock investors can benefit the most from this book whereas commodity and tangibles investors may find little that interests them.

Automating Your Financial Portfolio will be much less useful to naive investors using their computer expertise for investment analysis. The summaries of various investment-analysis techniques are oversimplified and misleadingly optimistic. In the same way that a weighty program cannot be written without substantial previous study and practice, so also a large investment program cannot be started without preparation. This book gives the impression that as soon as you plot some prices with your computer, the winning investments will become manifest.

BOOK'S STRUCTURE

Although Woodwell's first three chapters are enthusiastic, the real gist of the book lies in chapters 4 through 13. Each provides an introduction to a particular facet of investment or financial management—generally illustrated with sample screens or printed output from a few relevant programs. Each chapter concludes with a bibliography and a resource list of programs relevant to the topic of the chapter, a name and address of a source for the software, and the brand of computer for which the software is designed. Prices are not listed in the book but are occasionally mentioned in the text of the chapter. The illustrative tables and sample outputs all appear to have been provided by the program authors or vendors. This should not be taken as criticism; no single author could master the variety

(continued)



Technical analysis is more complex than is suggested in this book.

of approaches and different brands of computers and do such a timely job of reporting the results.

AN ASIDE

The most complete chapter is entitled "Portfolio Evaluation and Selection." It lists 23 programs in the resource section and shows several actual output pages or displays from each of eight programs. Although fundamental analysis is mentioned and about half of the illustrations show portfolio-inventory programs, the thrust of the chapter is toward technical stock analysis. Unfortunately, the explanation of technical analysis implies that stock-market prices are controlled by Kondratieff (55-year) cycles, 10-year cycles, and election (4-year) cycles and that all you have to do is plot stock-market price data to find the key to timing wise investment decisions. Cyclic theory is but one of several important parts of technical analysis. Technical analysis, in my opinion, is more complex and subjective than this book suggests.

The slight treatment of fundamental stock analysis is at variance with common practice. No matter what most stock investors' principal method of stock selection is, they all use a little fundamental analysis, which doesn't receive the usual equal treatment found in introductory texts. *Automating Your Financial Portfolio* devotes one page to fundamental stock analysis plus a short description of the Dow Jones Market Microscope. No sample outputs from any fundamental-analysis program are shown in the "Portfolio Evaluation and Selection" chapter. (However, a VisiCalc template for the very fine fundamental stock analysis method of the National Association of Investment Clubs is illustrated in the appendix of one of the introductory chapters.) This omission is hard to understand considering that the book publisher and the publisher of the Dow Jones Market Microscope are related companies.

The weakest technical chapter may be "Commodities and Stock Options Trading." The introductory material is superficial; it treats commodities as highly leveraged stocks. The only example program shown for commodity analysis is Compu Trac, which is primarily a technical stock-analysis program. No commodity programs are listed in the resource list.

Stock options are not explained, but 13 sentences are devoted to the Stock Options Analysis Program. This short explanation concentrates on a numerical integration used in calculating the expected profit on an option purchase, but it doesn't give much of an overview of the total function of the program. Two pages of graphs and printouts are reproduced from which a knowledgeable investor can get a good idea of the functioning of the program. The resource list also includes two option-analysis programs.

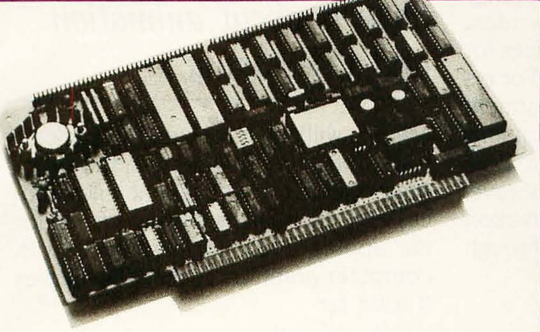
Other chapters cover "Cash and Budget Management" (ten programs listed, of which one has sample outputs shown), "Information Utilities" (six information services and five financially oriented terminal programs listed; short sessions with Dow Jones and The Source are illustrated), and "Debt Securities Analysis" (one program listed and sample output shown). Other chapters cover tax, estate, and real estate planning. The chapter called "Portfolio Evaluation and Selection" lists database-management programs and a chapter on "Tracking Tangibles" lists general graphing programs. But the chapter on evaluating portfolios could have been called "General Inventory Systems." Specialized investment-portfolio inventory systems are included in another chapter devoted to general database-management programs.

It is often the case that by the time any book concerning microcomputers is published it is already out of date. This book has not escaped that fate. The programs reported, while not exhaustive, seem to be a fair representation of what was available in early 1983 before many of them were released in IBM versions. My quick survey indicates that 60 percent of the listed programs are shown as being available in Apple versions, but only 17 percent are shown as being available in versions for the IBM PC. During this last year, however, the count has nearly equalized between

(continued)

LOMAS DATA PRODUCTS PRESENTS:

THUNDER 186



THUNDER 186 offers the following standard features:

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- *256K bytes of RAM*
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THUNDER 186 provides the earth shanking performance you have come to expect from LOMAS DATA PRODUCTS. THUNDER 186 is a complete SIXTEEN BIT SINGLE BOARD COMPUTER on a standard size S100 bus board. THUNDER's low price includes Concurrent CP/M-86* version 3.1. This allows the user to run PC-DOS**** programs, as well as, CP/M-86* programs on the same system. And, for those users that prefer, MS-DOS*** is also available.

TEST: THUNDER 186 BENCHMARK.

In our April '84 advertisement, we compared the benchmarks of our other advanced CPU products, against the COMPUPRO CPU86/87 10 Mhz. The test consisted of assembling the example BIOS (BIOS. A86) distributed with standard CP/M-86. The operating system used was CP/M-86. Now, we put THUNDER 186 to the same test . . .

	LIGHTNING ONE™ 10 MHZ	**COMPUPRO CPU86/87 10 MHZ**	**LIGHTNING 286™ 6 MHZ**	**THUNDER 186 8 MHZ**
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BOARD SET COST LIST PRICE AS TESTED	$2545.00	$3040.00	$3290.00	$1595.00
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Circle 215 on inquiry card.

IBM and Apple personal computers.

Network technology has definitely progressed since this book was written. Many stockbrokers provide services for computer and terminal owners. For example, E. F. Hutton provides investment news and research information on line. Several stockbrokers, in addition to Dow Jones, The Source, and CompuServe, provide delayed stock-price information and some accept orders placed through personal computers.

OTHER PUBLICATIONS

How does *Automating Your Financial Portfolio* compare to other books in the field? There aren't any directly comparable books, but readers may find *The Investor's Guide to Software* by Longman Financial Services Publishing (1983) useful. The *Investor's Guide*, revised annually, is organized very similarly to *Automating Your Financial Portfolio*, except that it makes no attempt to explain investment methods. Each program is given one page of which only about 100 words are devoted to explaining the program. The sample printouts and screen displays in *Automating Your Financial Portfolio* are more informative, but *The Investor's Guide* gives prices. *The Investor's Guide* and *Automating Your Financial Portfolio* would complement each other quite nicely.

ART AND GRAPHICS ON THE APPLE II/IIE

Reviewed by Kevin Woodhouse

From picture to picture in *Art and Graphics on the Apple II/IIe*, William H. DeWitt attempts to expand the artistic imagination into accepting the field of computer graphics. With an emphasis on creativity, he tries to convince the novice programmer or the experienced artist that Apple art is a link between imagination and a final project of color animation, videotaped and set to music. This is quite a lot of material to subject a beginner to in 128 pages. As successful or unsuccessful as he is at this, the book does not portray an understanding of high- and low-resolution graphics, but it makes up for it with an imaginative approach to many hours of computer fun.

DeWitt, who has taught computer graphics at the University of Rochester and is the president of Computer Art, gives his reasons for writing this book and throws down all his cards. His readers will either be turned off or captured totally by the latest in the Wiley Press Guides to self-taught microprocessing. Although he deserves credit for his approach to mixing humor with computer graphics, at times he carries it a bit far.

The second half of the book is about animation and videotaping.

GETTING STARTED

DeWitt assumes you know BASIC pretty thoroughly and in the first chapter sets the tone for the rest of the book: short and sweet. He wisely keeps the reader interested by frequent references to sections that follow. Moving quickly through the next two chapters, he informs the reader about low-resolution graphics. The book is largely based on low resolution, as DeWitt believes it's more exciting than high resolution. If he were more technical, he could have made this more interesting for serious programmers. However, opting for imagination, it seems to fit a have-fun/no-pressure approach to programming.

Chapters 4 and 5 summarize high-resolution art. These two chapters contain more technical data than the rest of the book. Similar to the preceding two chapters, 4 and 5 round out the first section of exposure to Apple graphics.

CREATING SHAPES

Part 2 is made up of chapters 6, 7, and 8. It is devoted to shapes, tables, and pictures. There is only one slight reference to using two-page graphics. The reader begins to see the power and practical use of Apple graphics rather than the simple fun of Apple art. I recommend that this section be read all at once to spark an interest in the final half of the book, which is on animation and videotaping. DeWitt includes 15 color photos, mostly artwork, to give you an idea of what you will see on the screen.

In the last five chapters, 9 through 13, the reader moves from animating to capturing animation on film. One of DeWitt's past employers, Eastman Kodak, plays an important role in this section, as there are several references

(continued)

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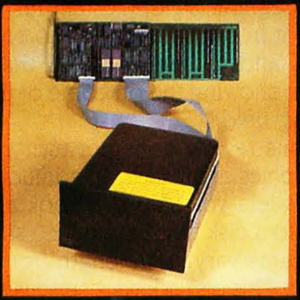

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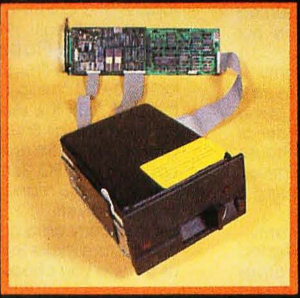

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to coupling its equipment with your animated artwork. It is here that we see the overall project and the use of graphics on the computer. For those of us who don't have this hardware, we can skip this section and not lose much information on graphics. Although it is a complete step-by-step procedure on filmmaking, keep in mind the book was written for the graphic artist to expand computer skills.

OVERVIEW

To complete the introductory course on graphics, the reader should be equipped with a glossary of terms to understand what is going on. Nonetheless, the beginning graphics enthusiast will benefit from this exposure to computer art and, in the end, will thank DeWitt for showing the outcome of this expanding field.

But if this review does not turn you into a graphics enthusiast, an additional 10 dollars lets you skip the book and move on to a disk that holds all 60 sample programs varying in length from 3 to 52 lines. This disk allows a serious approach to this field for the serious programmer.

Despite an occasional lack of detail, DeWitt's book successfully captures the artist or even the filmmaker's imagination and creates the urge to take a second step in Apple graphics. ■

Bruce R. Evans is a family physician (1 Hopecrest Cres., Scarborough, Ontario M1K 2K3, Canada) practicing in Toronto, Ontario.

Jeff Campbell (9296 West 98th Place, Broomfield, CO 80020) is the graphic designer/photographer at Campbell Photo/Graphics in Denver.

Paul Ross (6800 Fleetwood Rd. #418, McLean, VA 22101) is a research engineer who writes his own investment programs.

Kevin Woodhouse is a microcomputer and math teacher at Dublin School in Dublin, NH 03444, with a particular interest in computer cartography and research.

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EVENT QUEUE

September 1984

● DEC SEMINARS
Technical and Management Seminars for Professionals, various sites in the U.S. Subject areas: system-performance management, networking, personal computing, applications design and programming, real-time applications design, and management development. On-site seminars can be arranged. Contact Educational Services, Seminar Programs BUO/E58, Digital Equipment Corp., 12 Crosby Dr., Bedford, MA 01730, (617) 276-4949. *September*

● MANAGERIAL SEMINARS
Computer Competence Seminars, Boston University Metropolitan College, Boston, MA. A series of hands-on presentations tailored for managers who know little or nothing about computers and for those who wish to sharpen their computing skills. On the docket are "BASIC for Managers," "Getting Started with Lotus 1-2-3," and many others. Fees range from $225 to $595. In-house programs can be organized. Contact Joan Merrick, University Seminar Center, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020. *September*

● RAINBOW SEMINARS
All-Hands-On, Boston, MA, and Chicago, IL. A series of applications seminars featuring the DEC Rainbow 100. Contact Carol Ericson, BUO/E50, Educational Services, Digital Equipment Corp., 12 Crosby Dr., Bedford, MA 01730, (617) 276-4572. *September*

● COURSES FROM ICS
Courses from Integrated Computer Systems, various sites throughout the U.S. Among the courses offered are "Computer Network Design and Protocols" and "Data Communications." Fees are generally $895. For more information, contact Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (800) 421-8166; in California, (800) 352-8251 or (213) 417-8888. *September-October*

● ERGONOMICS CONFERENCE
World Conference on Ergonomics in Computer Systems, various sites throughout the U.S. and Europe. Ergonomic experts and computer professionals and users will exchange information and observations. Contact Computer Psychology Inc., 54 East Main St., POB 16, Mendham, NJ 07945, (201) 543-9009. In Europe, Telefonaktiebolaget LM Ericsson, LM Ericssons väg 4-8, S-12625 Stockholm, Sweden; tel: (8) 7190000. *September-October*

● HIGH-TECH TUTORIALS
Tutorial Short Courses from Hellman Associates, London, England, and various sites in the U.S. Among the courses offered are "VLSI Design," "Digital Control," and "Error Correction." Fees are generally $895. Contact Hellman Associates Inc., Suite 300, 299 California Ave., Palo Alto, CA 94306, (415) 328-4091. *September–October*

● SEMINARS FOR PROFESSIONALS—Professional Development Seminars, various sites throughout the U.S. Topic areas: data communications, database management, EDP operations, microcomputers, software engineering, CAD/CAM, IBM mainframes, office automation, and others. Fees range from $195 to $1095. Contact Institute for Advanced Technology, 6003 Executive Blvd., Rockville, MD 20852, (800) 638-6590; in Maryland, (301) 468-8576. *September-October*

● CONTINUING ENGINEERING EDUCATION—George Washington University, Continuing Engineering Education, Washington, DC. For a schedule, contact George Harrison, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-6106. *September-November*

● INDUSTRIAL ENGINEER PROGRAMS—1984 Institute of Industrial Engineers' Continuing Education Programs, various sites throughout the U.S. Among the programs on the agenda are "Robotics—Equipment, Applications, and Methodology" and "Effective Utilization of Microcomputers." A complete listing is available from the Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, GA 30092, (404) 449-0460. *September-December*

● INFORMATION PROCESSING SEMINARS—New York University Seminars in Information Processing, various sites throughout the U.S. "Fundamentals of Data Processing for Administrative Assistants and Secretaries" and "Managing Systems Projects" are two of the seminars offered. For a calendar listing and more information, contact School of Continuing Education, Seminar Center, New York University, 575 Madison Ave., New York, NY 10022, (212) 748-5094. *September-December*

● INTEL WORKSHOPS
Microcomputer Workshops, various sites throughout the U.S. and Canada. Intel, the semiconductor memory manufacturer, is offering more than 20 workshops on microprocessor applications. A brochure is available. Contact Customer Training, Intel Corp., 27 Industrial Ave., Chelmsford, MA 01824-3688, (617) 256-1374. *September-December*

● LECTURE SERIES
Montclair State College Colloquium Lecture Series and the Nobel Laureate Lecture Series, Richardson Hall, Room W-117, Upper Montclair, NJ. Topics to be addressed include "Can Civilization Survive Science and Technology?" and "Industrial Applications of Input/Output Analysis." Admission is free. Contact Professor Gideon Nettler, Department of Mathematics and Computer Science, Montclair State College, Upper Montclair, NJ 07043, (201) 893-4294. *September-December*

● PROFESSIONAL EDUCATION
Seminars from the Institute for Professional Education, various sites in the U.S. Programs in statistics, management, simulation and modeling, personal computers, and computer science. Contact the Institute for Professional Education, POB 756, Arlington, VA 22216, (703) 527-8700. *September-December*

● FUTURE DBMS
Fourth Generation Data Management Software, Washington, DC. Topics include user-friendly DBMS, applications generators, data dictionaries/directories, database designers, and decision-support systems. Registration fee: $650. Contact Software Institute of America Inc., 8 Windsor St., Andover, MA 01810, (617) 470-3880. *September* 10-11

● ELECTRONICS SHOWS
Midcon/84 and Mini/Micro Southwest-84, Dallas, TX. Concurrent conferences exploring practical applications and the state of the art of electronics, including computers, graphics, and networks. Contact Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *September* 11-13

● UNIX EXPOSITION
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and panel discussions. Contact Computer Faire Inc., 181 Wells Ave., Newton, MA 02159, (617) 965-8350. *September* 11-14

● EUROPEAN COMPUTER GRAPHICS—Eurographics '84, The Fifth Annual European Computer Graphics Congress, Copenhagen, Denmark. A congress with an international lineup of speakers and product exhibits. Contact Kenness International, 1 Park Ave., New York, NY 10016, (800) 235-6400; in New York, (212) 684-2010. *September* 12-14

● INTRO TO DATA COMMUNICATIONS—Introduction to Data Communications, Atlanta, GA. An overview of data-communications terminology, technology, hardware, and software. Participants will learn to design a batch data-collection system and estimate the response time of a multipoint circuit. Fee: $725. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *September* 12-14

● SOFTWARE EXPO
The Fifth Annual Software/Expo, Hyatt Regency, Chicago, IL. A conference and exposition. Contact Software/Expo, Suite 205, 2400 East Devon Ave., Des Plaines, IL 60018, (312) 299-3131. *September* 12-14

● TECHNOLOGY FOR DISABLED—Computer Technology for the Handicapped, Raddison South Hotel, Minneapolis, MN. A national conference and exhibit for special education, rehabilitation, and medical professionals. Presentations and workshops. Registration is $175. Admission to the exhibit floor only is $3. Contact Closing the Gap, POB 68, Henderson, MN 56044, (612) 665-6573 or (612) 341-8299. *September* 13-16

● GULF COAST COMPUTING
The Heart of Texas Computer Show, Bayfront Plaza, Corpus Christi. Seminars and displays. Contact Heart of Texas Computer Show, POB 12094, San Antonio, TX 78212, (512) 681-2248. *September* 14-16

● EFFICIENT COMPUTING TECHNIQUES—Microcomputers: Techniques for Improving Your Computer Efficiency, Valley Inn and Tavern, Waterville Valley, NH. Intensive two-day seminar, "Introduction to VisiCalc." Tuition is $495, or $679 with meals and lodging. Contact New Hampshire College, Resource Center, 2500 North River Rd., Manchester, NH 03104, (603) 668-2211, ext. 175. *September* 15-16

● SHOW IN GARDEN STATE
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● PEOPLE AND COMPUTERS
The 1984 SME World Congress on Human Aspects of Automation, Hotel du Parc, Montreal, Quebec, Canada. Contact Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500, ext. 369. *September* 16-19

● COMPUTERS AND MODERN WORLD—COMPCON Fall '84, Hyatt Regency Crystal City, Arlington, VA. Tutorials, panels, demonstrations, sessions, and papers will explore the theme "Small Computer (R)Evolution." Contact COMPCON Fall '84, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-8142. *September* 16-20

● MEDICINE, BIOLOGY, ENGINEERING—The Thirty-Seventh Annual Conference on Engineering in Medicine and Biology, Los Angeles Hilton, Los Angeles, CA. Papers, short courses, and scientific and commercial exhibits will be featured. Contact The Alliance for Engineering in Medicine and Biology, Suite 402, 4405 East-West Highway, Bethesda, MD 20814, (301) 657-4142. *September* 17-19

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● ADA WORKSHOP
Future Ada Environment Workshop, Miramar Hotel By-the-Sea, Santa Barbara, CA. Workshops, addresses, presentations, working groups, and discussions. Registration: $400 to $700 depending on room choice. Contact ACM AdaTEC Future Ada Environment Workshop, TRW R2/1134, One Space Park, Redondo Beach, CA 90278, or register directly with Carolyn Gannon, GRC, POB 6770, Santa Barbara, CA 93160. *September* 17-20

● AIR SAFETY AND COMPUTERS—Special Committee 156 Meeting, Washington, DC. Special Committee 156 will discuss possible safety problems caused by portable computers on airplanes and what standards are needed. The standards could affect the in-flight use of some portable computers. Meetings are open and generally begin at 9:30 a.m. Contact Radio Technical Commission for Aeronautics, 1425 K St. NW, Washington, DC 20005, (202) 682-0266. *September* 18-19

● KENTUCKIANA EXHIBITION
CompuFest '84, Commonwealth Convention Center, Louisville, KY. Computer consultant services, approximately 100 hardware, software, peripheral, and word-processing system vendors, and technical sessions. A full day's worth of seminars costs $15. Registration fee is $2. Contact the Kentucky Society of CPAs, 310 West Liberty St., Louisville, KY 40202, (502) 589-9239. *September* 18-20

● OFFICE PRODUCTS IN OK CITY—The First Annual Southwest Office Products Show, Oklahoma City, OK. Contact SWOPS, POB 950, Norman, OK 73070, (405) 329-3660 or (918) 587-9550. *September* 18-20

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● SHOW IN INDONESIA
The Third International Business and Personal Computer Exhibition, Fair Grounds, Jakarta, Indonesia. Contact Overseas Exhibition Services, 11 Manchester Square, London W1M 5AB, England; tel: 01-486 1951; Telex: 24591 MONTEX G. *September* 18-22

● PARISIAN COMPUTING
The Thirty-Fifth SICOB, International Exhibition of Data Processing, Teleprocessing, Communication, Office Procedures, and Office Systems, CNIT, Paris-La Défense, Paris, France. Microprocessing and videotex will be major highlights of the exhibition. International visitors presenting their passports will have a special reception room. Some of the congresses and conferences will feature simultaneous interpretation in English and French. Contact International Trade Exhibitions in France, 8 West 40th St., New York, NY 10018, (212) 869-1720. *September* 19-28

● EDUCATIONAL CONFERENCE
The First North Carolina Educational Microcomputer Conference, Benton Convention Center and Hyatt Hotel, Winston-Salem. Educational sessions, hands-on workshops, and product displays. A network of various computers will be set up. Contact Jeanette Gann, NC Regional Education Center, POB 21889, Greensboro, NC 27420, (919) 379-5764. *September* 20-21

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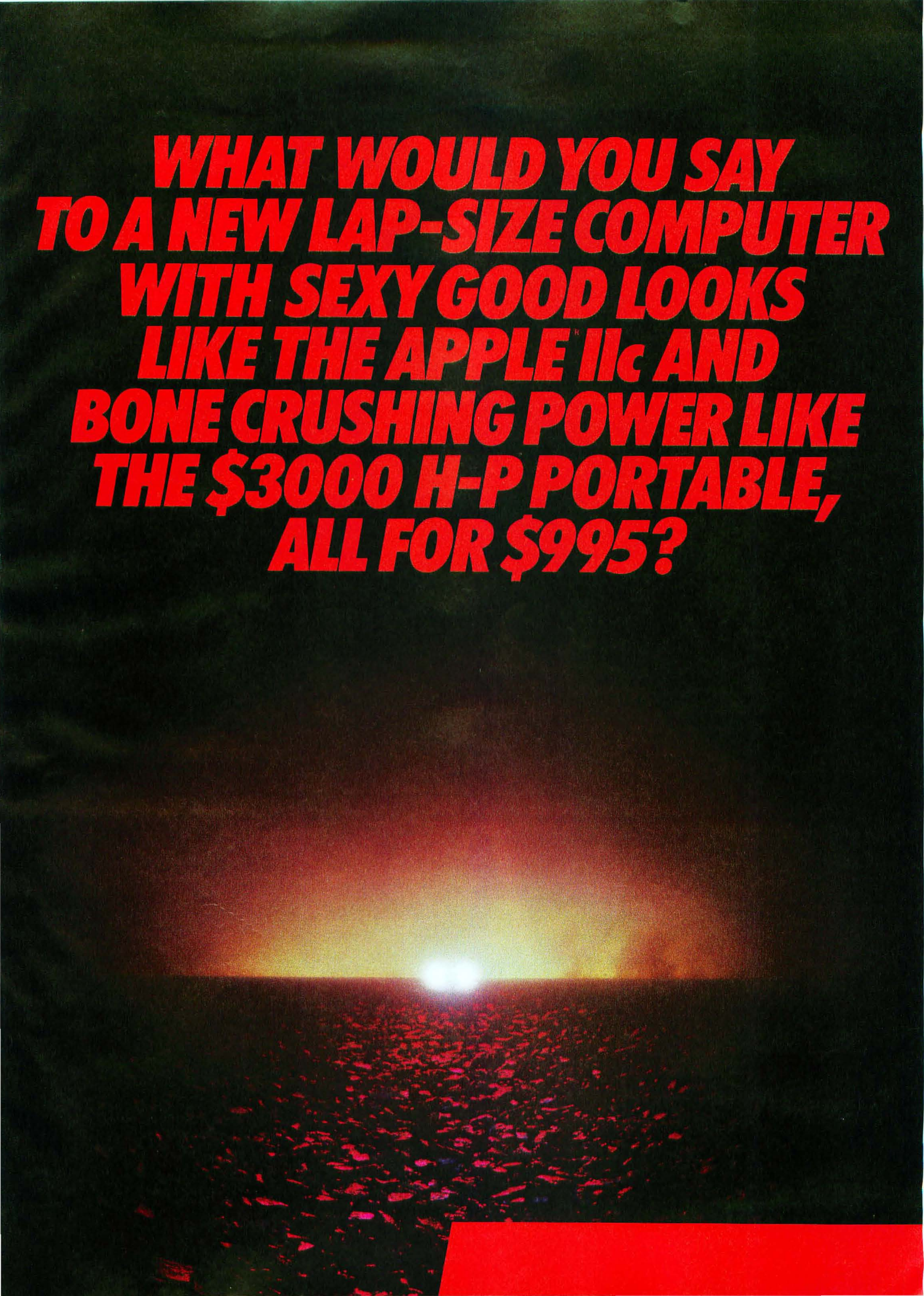

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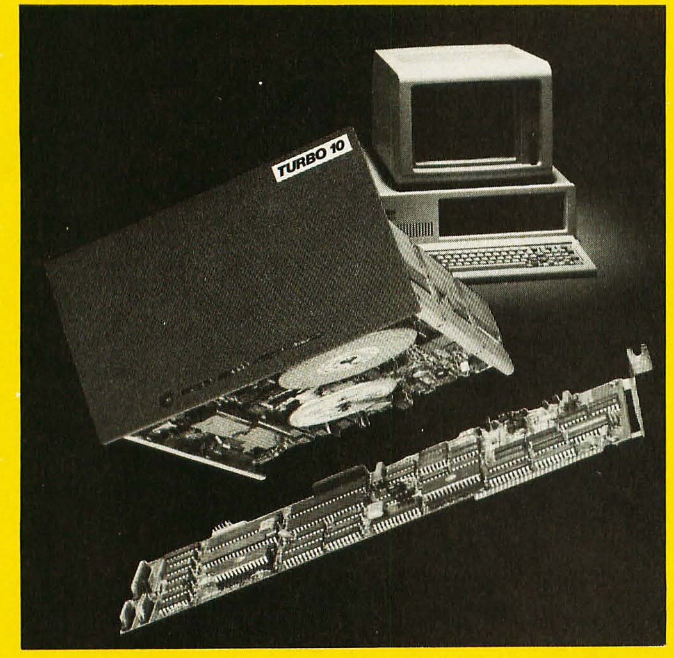

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● OFFICE AUTOMATION IN OTTAWA—The Seventh Annual Ottawa Computer and Office Automation Show, Lansdowne Park, Ottawa, Ontario, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791. *September* 26-27

● COMPUTERS, COMMUNICATIONS, AND CONTROL
Eurocon 84, The Sixth European Conference on Electrotechnics, Brighton, England. A conference that seeks to identify the impact of computer-based technology on communications and control. Contact Manager, Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, England; tel: 01-240 1871, ext. 222; Telex: 261176. *September* 26-28

● MID-ATLANTIC SHOW
The Fifth Annual Mid-Atlantic Computer Show and Office Equipment Exposition, Convention Center, Washington, DC. Contact CompuShows Inc., POB 3315, Annapolis, MD 21403, (800) 368-2066; Annapolis, (301) 263-8044; Baltimore, 269-7694; District of Columbia, 261-1047. *September* 27-30

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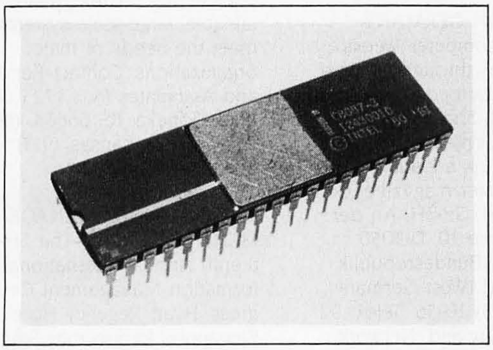

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● SHOWS IN GERMANY
Chip Microcomputer Weeks, various sites throughout West Germany. Microcomputer products, trends, and applications will be demonstrated. Sponsored by *Chip*, a leading German computer magazine. Contact Network GmbH, An der Friedenseiche 10, D-3050 Wunstorf 2, Bundesrepublik Deutschland (West Germany); tel: (0 50 33) 10 56; Telex: 92 45 45. In England, Network Events Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, England; tel: (02 80) 81 52 26; Telex: 83111. *October-November*

● BRUSH-UPS FOR ENGINEERS
Continuing Engineering Education Courses, George Washington University, Washington, DC. Among the course titles are "Microcomputer Application Workshop: Evaluating Microcomputer Software Packages" and "Workshop in Data Communications for Microcomputers." Tuition ranges from $625 to $875. Contact George Harrison, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-6106. *October-December*

● TECHNOLOGY FOR DISABLED—Discovery '84: Technology for Disabled Persons, Chicago, IL. Presentations, demonstrations, and exhibits on computers, technological products, and services for disabled persons. Registration is $175. Contact Office of Continuing Education, University of Wisconsin-Stout, Menomonie, WI 54751, (800) 457-8688; in Wisconsin, (800) 227-8688. *October 1-3*

● INFO/MANAGEMENT CONFERENCE—Information Management Exposition and Conference: Info 84, Coliseum and Sheraton Centre Hotel, New York City. Contact Banner & Greif Ltd., 110 East 42nd St., New York, NY 10017, (212) 687-7730. *October 1-4*

● INDUSTRIAL INFO SYSTEMS
Feedback '84, The Ninth Annual Data Structured Systems Development Users' Conference, Topeka, KS. The focus will be on the specific problems of engineering reliable, maintainable, large-scale systems that meet the needs of major organizations. Contact Ken Orr and Associates Inc., 1725 Gage Blvd., Topeka, KS 66604, (800) 255-2459; in Kansas, (913) 273-0653. *October 2-4*

● GLOBAL INFO/MANAGEMENT CONGRESS—The Sixteenth Annual International Information Management Congress, Hyatt Regency Hotel, Singapore, Republic of Singapore. Seminars, displays, and more than 30 conference sessions. Contact IMC Infomatics '84, POB 34404, Bethesda, MD 20817, (301) 983-0604. *October 2-4*

● NORTHWEST ELECTRONICS SHOW—Northcon/84 and Mini/Micro Northwest-84, Seattle, WA. Topics include automation, CAD/CAM, LANs, and personal computing. Contact Electronic Conventions Management Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *October 2-4*

● ADA WORKSHOP
Workshop in Ada, Atlanta, GA. See September 18-21. *October 2-5*

● PC EXPO
PC-World Exposition, Market Hall, Dallas, TX. Contact Mitch Hall Associates, POB 860, Westwood, MA 02090, (617) 329-8090. *October 3-5*

● MOTION CONTROL SEMINAR—Electronic Motion Control Seminar, Philadelphia, PA. Contact Electronic Motion Control Association, Suite 1200, 230 North Michigan Ave., Chicago, IL 60601, (312) 372-9800. *October 8-9*

● VIRGINIA IS FOR COMPUTERS—The Tidewater Ninth Annual Computer Fair,

(continued)

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It's a fast structured programming language. It's also a true development system, complete with its own command-oriented operating system executive; fast one-pass compiler; and full-screen cursor-driven editor; and library of time-saving routines. In short, PROMAL is the complete set of tools that small system programmers have been waiting for.

PROMAL is fast.
In benchmarking, PROMAL has proven itself to be significantly faster than any of the programming languages we tested it against. It executes much faster than BASIC...20 to more than 100 times faster, to be exact. And it's nearly twice as fast as FORTH. The PROMAL compiler is so fast that it can compile a 100-line source program in 8 seconds or less. In a recent test, the PROMAL compiler compiled 5 times faster than Pascal on the Commodore 64. And, not only is it fast in compile and run time, it also speeds programming development time.

PROMAL is easy to learn... and to use.
It's easier to learn than Pascal or C or FORTH. It makes use of powerful structured statements, like IF-ELSE, WHILE, REPEAT, FOR, and CHOOSE. Indentation of statements is part of the language's syntax, so all programs are neatly and logically written. There's even an automatic "indent" and "undent" function in the editor that supports the syntax requirement. In other words, you can begin programming in PROMAL almost from the minute you get the program disk. There are no line numbers to complicate your programming. And comments don't take up memory space, so you can document programs completely. And with the full-screen editor, you can speed through program development with saves to memory and compilation from memory workspace.

PROMAL is powerful and elegant.
PROMAL overcomes the performance limitations of small systems...limitations that are inherent to all small systems. It gives you access to the power of the machine. But it doesn't require you to learn the complexity of the system. In other words, you can have performance the easy way... without knowing how to program in machine language and without needing to know Pascal or one of the other relatively "complex" languages. It was developed from the very beginning to work on small systems... elegantly. With PROMAL, there's no awkwardness of implementation as there is with so many other languages which were ported over from minis and mainframes and forced to fit the small system market.

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- Procedures w/passed arguments
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- Control Statements: IF-ELSE, IF, WHILE, FOR, CHOOSE, BREAK, REPEAT, INCLUDE, NEXT, ESCAPE, REFUGE
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- Memory resident
- Allows multiple user programs in memory at once
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- Full-screen, cursor driven
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LIBRARY
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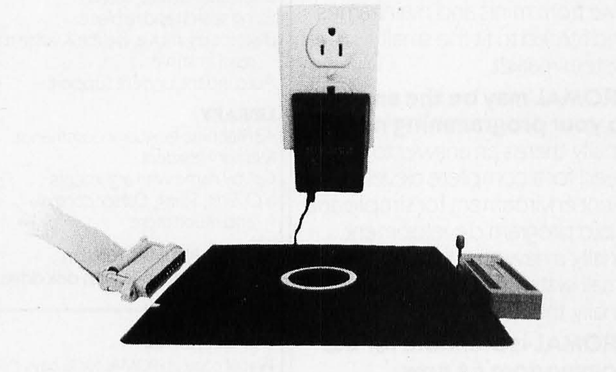

EVENT QUEUE

Radio Amateur Hamfest/Electronic Flea Market, Virginia Beach Pavilion, Virginia Beach, VA. Dealers, a giant flea market, displays, and forums. Advance tickets are $4; at the door, $5. Contact Jim Harrison, 1234 Little Bay Ave., Norfolk, VA 23503, (804) 587-1695. *October 8-9*

● ANNUAL CONFERENCE OF ACM—ACM 1984 Annual Conference, Hilton Hotel, San Francisco, CA. Papers, sessions, and panel discussions will address the theme "The Fifth Generation Challenge." Contact Association for Computing Machinery, 11 West 42nd St., New York, NY 10036, (212) 869-7440. *October 8-10*

● NETWORK CONFERENCE The Ninth Conference on Local Computer Networks, Minneapolis, MN. Papers, conference sessions, and tutorials. The theme is "Local Computer Networks—The Exploding Marketplace." Contact Ninth Conference on Local Networks, c/o Harvey Freeman, Architectural Technology Corp., POB 24344, Minneapolis, MN 55424. *October 8-10*

● RELIABILITY ENGINEERING Reliability Engineering, Testing, and Maintainability Engineering, University of California, Los Angeles. Contact Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering, Building 16, Room 200-B, University of Arizona, Tucson, AZ 85721, (602) 621-6120. *October 8-12*

● INFO SYSTEMS CONFERENCE and EXPO—INTECH, The Integrated Information Technology Conference and Exposition, Convention Center, Dallas, TX. Seminars, sessions, and panels addressing total information systems integration. Contact National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (800) 638-8510; in Maryland, (301) 459-8383. *October 9-11*

● SOUTHWEST COMPUTING The Third Annual Southwest Computer Conference, Convention Center, Tulsa, OK. A business and industry event featuring more than 50 seminars as well as 250 exhibits. Contact SWCC, POB 950, Norman, OK 73070, (405) 329-3660 or (918) 587-9550. *October 9-11*

● MID-WEST ELECTRONICS The Mid-America Electronics Convention, MAECON/84, St. Louis, MO. Exhibits, seminars, tutorials, and symposia. Contact Electronic Representatives Association, 20 East Huron St., Chicago, IL 60611, (312) 649-1333. *October 10-11*

● NETWORK ARCHITECTURE Introduction to Network Architectures, Atlanta, GA. This course provides an introduction to network architectures and prepares participants to pursue the study of specific network components applicable to their needs. The fee is $795. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *October 10-12*

● NETWORKS EXPLORED LocalNet '84, Sheraton Harbor Island Hotel, San Diego, CA. Speakers, papers, and exhibitions will look at local network technology and the effects of office automation. Contact Online Conferences Inc., Suite 1190, 2 Penn Plaza, New York, NY 10121, (212) 279-8890. *October 10-12*

● PROJECT MANAGEMENT SEMINAR—Software for Project Management and Estimating, Washington, DC. See September 20-21. *October 11-12*

● GOLDEN STATE EXPO Computer Expo and PC Faire, Cal Expo, Sacramento, CA. Contact Computer Expo & PC Show, Suite 395, 2020 Hurley Way, Sacramento, CA 95825, (916) 924-9351. *October 11-14*

● EDUCATIONAL COMPUTER FAIR, Fourth Annual Educational Computer Fair, Cleveland, OH. Contact Educational Computer Consortium of Ohio, 4777 Farnhurst Rd., Cleveland, OH 44124, (216) 291-5225. *October 12-13*

● COMPUTERS IN SUNSHINE Great Southern Business and Computer Show and Seminars, Centroplex Expo Centre, Orlando, FL. Seminars and exhibits of hardware, software, peripherals, and accessories. Contact Great Southern Computer

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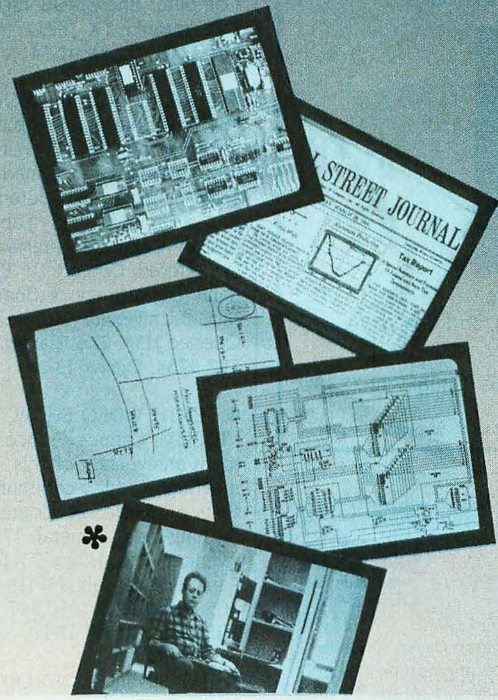

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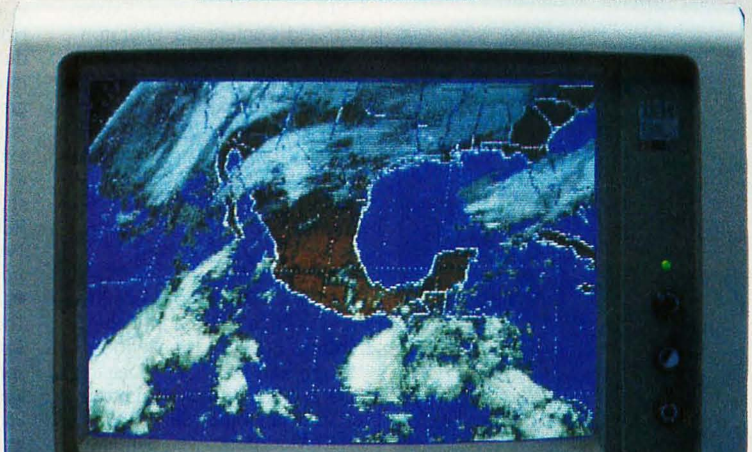

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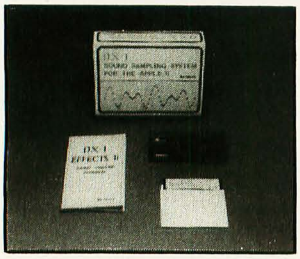

EVENT QUEUE

Shows, POB 655, Jacksonville, FL 32201, (904) 356-1044. *October* 12-14

● LONE STAR COMPUTING
The Second Annual Heart of Texas Computer Show, Convention Center, San Antonio, TX. Exhibits of computers, games, robots, and other high-tech products. Contact Heart of Texas Computer Show, POB 12094, San Antonio, TX 78212, (512) 681-2248. *October* 12-14

● COMPUTERS IN LABORATORY—Laboratory Computer Interfacing, McGill University, Montreal, Quebec, Canada. Two short courses, "Computers in the Laboratory" and "Laboratory Computer Interfacing," are offered. Contact Dr. Eric Salin, Department of Chemistry, McGill University, Montreal, Quebec H3A 2K6, Canada, (514) 392-5784. *October* 13-14

● TENTH VIDEO SHOW
VIDCOM, Cannes, France. The tenth anniversary of this meeting of video-communications professionals. Contact Commissariat Général, 179, Avenue Victor-Hugo, 75116 Paris, France; tel: (33) (1) 505.14.03; Telex: 630.547 MIDORG. *October* 13-17

● UNIX INSIDE AND OUT
UNIX Operating System Exposition and Conference, Sheraton Centre Hotel and Marina Exposition Complex, New York City. Seminars, social functions, and 350 exhibition booths. Contact National Expositions Co. Inc., 14 West 40th St., New York, NY 10018, (212) 391-9111. *October* 16-18

● WEST COAST EXPO, CONFERENCE—The West Coast Electronic Office Expo and Conference, EOE '84, Convention Center, San Jose, CA. More than 200 exhibits. Contact Cartlidge & Associates Inc., Suite 205, 4030 Moorpark Ave., San Jose, CA 95117, (408) 554-6644. *October* 16-18

● OFFICE COMPUTERS
The Sixth Annual Calgary Computer and Office Automation Show, Roundup Centre, Calgary, Alberta, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791. *October* 17-18

● COMPUTERS, COMMAND, CONTROL—The Second Annual Symposium and Exhibition of AFCEA, Inn at Executive Park, Kansas City, MO. The theme for this year's symposium is "The Role of Knowledge-Based Systems in Command and Control." Panel discussions, paper presentations, and exhibits. Contact Armed Forces Communications and Electronics Association, POB 456, Leavenworth, KS 66048, (913) 651-7800. *October* 17-19

● ASIS MEETING
The Forty-Seventh Annual Meeting of American Society for Information Science, Franklin Plaza, Philadelphia, PA. This year's theme is "1984—Challenges to an Information Society." Contact 1984 ASIS Convention, The Automated Office, 3401 Market St., Philadelphia, PA 19104. *October* 21-26

● HOOSIER COMPUTERFEST
Indy/Con '84, Indiana Convention Center and Hoosier Dome, Indianapolis. The largest microcomputer/electronics exhibition and conference in the state. Contact Indy/Con, 5160 East 65th St., Indianapolis, IN 46220, (317) 842-3024. *October* 23-24

● COMPUTERS IN ARTS
Symposium on Small Computers in the Arts, University Hilton Hotel, Philadelphia, PA. Introductory and advanced courses in computer animation, music, graphics, interfaces, and legal issues complemented by talks, exhibits, research presentations, a computer art gallery, and film shows. Contact Symposium, POB 1954, Philadelphia, PA 19105. *October* 25-28

● PC FAIRE
The Second Annual PC Faire, San Francisco, CA. Exhibits, speakers, seminars, and workshops. Contact Computer Faire Inc., 570 Price Ave., Redwood City, CA 94063, (415) 364-4294. *October* 26-28

● PROGRAM FOR PROFESSIONALS—Wescon/84 and Mini/Micro West-84, Anaheim, CA. Topics include artificial intelligence, computer peripherals, graphics, speech recognition/synthesis, and telecommunications. Contact Electronic Conventions Manage-

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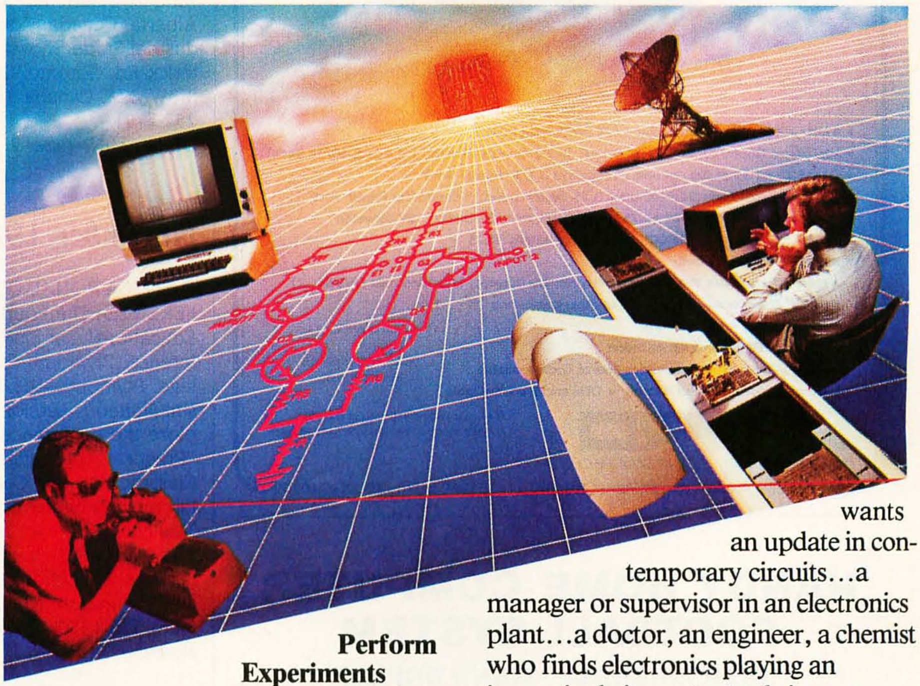

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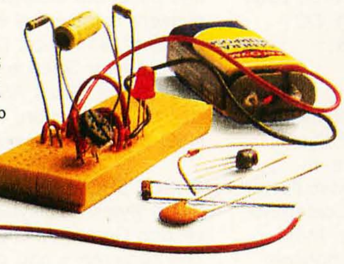

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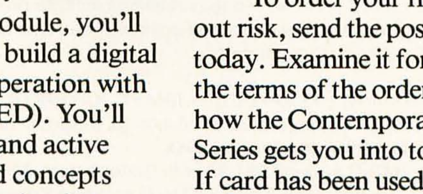

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ment, 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965.
October 30-November 2

● COMPUTER SHOW IN EDMONTON—The Second Annual Edmonton Computer and Office Automation Show, Convention Centre, Edmonton, Alberta, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791.
October 31-November 2

November 1984

● EDUCATIONAL CONFERENCE—The Fourth Annual Educational Computing Conference, Plymouth State College, Plymouth, NH. Six simultaneous sessions will explore the conference themes "Practical Applications in the Classroom" and "Computer Literacy for Students and Teachers." Contact Ms. Peggie Riley, Department of Computer Science, Plymouth State College, Plymouth, NH 03264, (603) 536-1550, ext. 533.
November 3

● MEDICAL COMPUTING The Eighth Annual Symposium on Computer Applications in Medical Care, SCAMC, Washington Hilton Hotel, Washington, DC. A varied program covering new, controversial, and state-of-the-art topics on computers and health care. Contact Gail Mutnik, SCAMC Symposium Coordinator, Office of Continuing Medical Education, George Washington University Medical Center, 2300 K St. NW, Washington, DC 20037, (202) 676-8928.
November 4-7

● ERGONOMICS CONFERENCE The First International Symposium of Ergonomics, Industrial Design, and Manufacturing, Ergodesign '84, Conference and Exhibition Centre, Montreux, Switzerland. A noncommercial exhibit of equipment that meets ergonomic needs. Contact Ergodesign '84, Conference and Exhibition Centre, POB 97, CH-1820, Montreux, Switzerland tel: (021) 630440; Telex: 453 222.
November 6-9

● WESTERN EDUCATORS MEET—The Eighth Annual Western Educational Computing Conference, Vacation Village, San Diego, CA. Refereed papers on computer science, humanities and the fine arts, CAI, administration, and research support. Contact Dr. Virginia S. Lashley, Glendale College, 1500 North Verdugo Rd., Glendale, CA 91208. *November 15-16*

● FORTH CONVENTION The Sixth Annual FORTH Convention and Banquet, Hyatt Palo Alto, Palo Alto, CA. Contact FORTH Interest Group, POB 1105, San Carlos, CA 94070, (415) 962-8653. *November 16-17*

● FARM COMPUTER CONFERENCE—The 1984 Purdue On-Farm Computer Use Conference and Trade Show, Purdue University, West Lafayette, IN. Workshops will complement exhibits and conference sessions. Contact Continuing Education Business Office, Stewart Center, Room 110, Purdue University, West Lafayette, IN 47907.
November 18-20

● CANADIAN ATLANTIC SHOW Moncton Computer Exhibition '84, Moncton, New Brunswick, Canada. Home computers, video games, and office automation equipment will be displayed. Contact Anne LeBlanc, Commerce Building, University of Moncton, Moncton, New Brunswick E1A 3E9, Canada, (506) 858-4555.
November 23-25

● SIMULATION CONFERENCE Winter Simulation Conference, Sheraton Dallas Hotel, Dallas, TX. Papers, tutorials, sessions, and panel discussions will complement commercial exhibits. Contact Udo Pooch, Department of Computer Science, College of Engineering, Texas A&M University, College Station, TX 77843, (409) 845-5498. *November 28-30*

● KIDS SHOW Bits & Bytes, Disneyland Convention Center, Anaheim, CA. This conference and exposition attempts to show educators, parents, and children how to use computers in the home and classroom. Contact Information Processing Group, Suite 113-150, 350 South Lake Ave., Pasadena, CA 91101, (818) 792-5111.
November 30-December 2 ■

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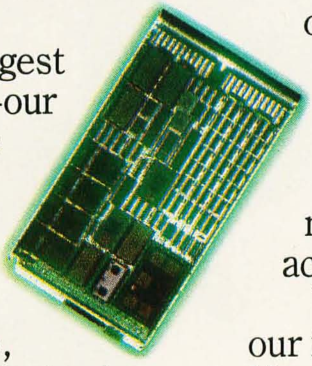

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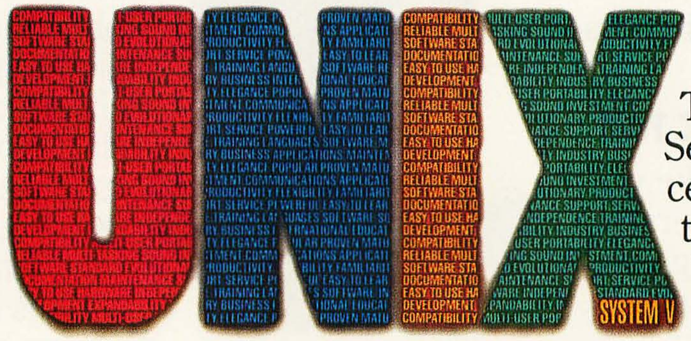

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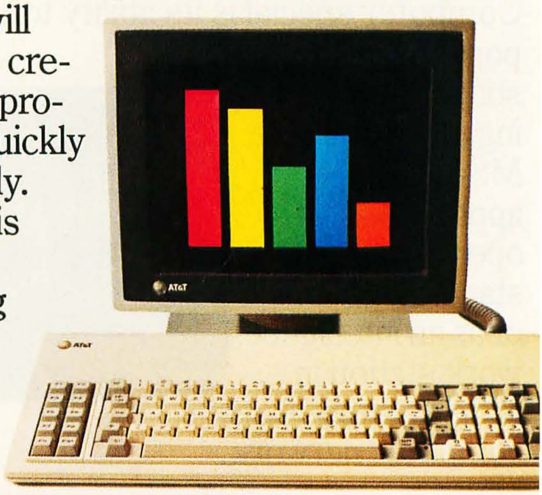

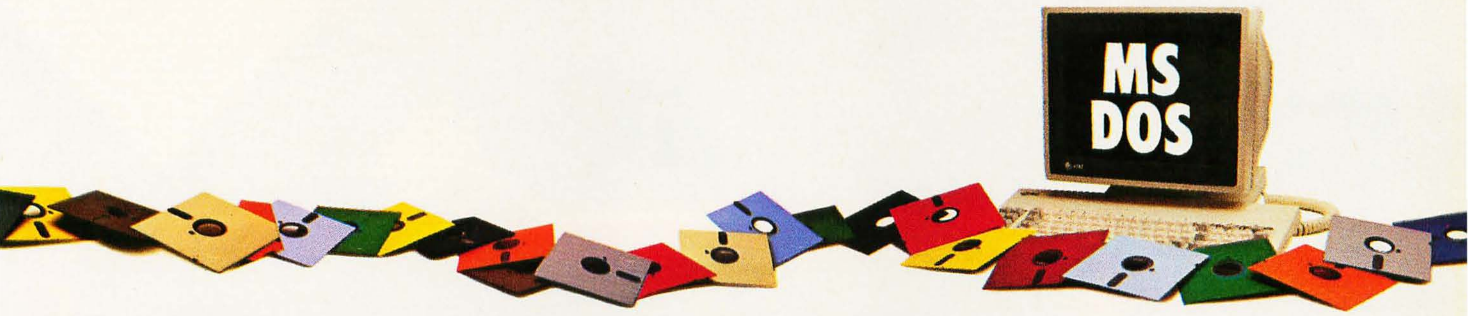

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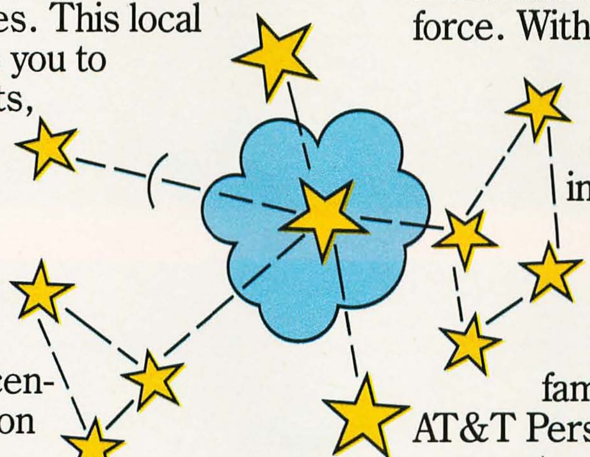

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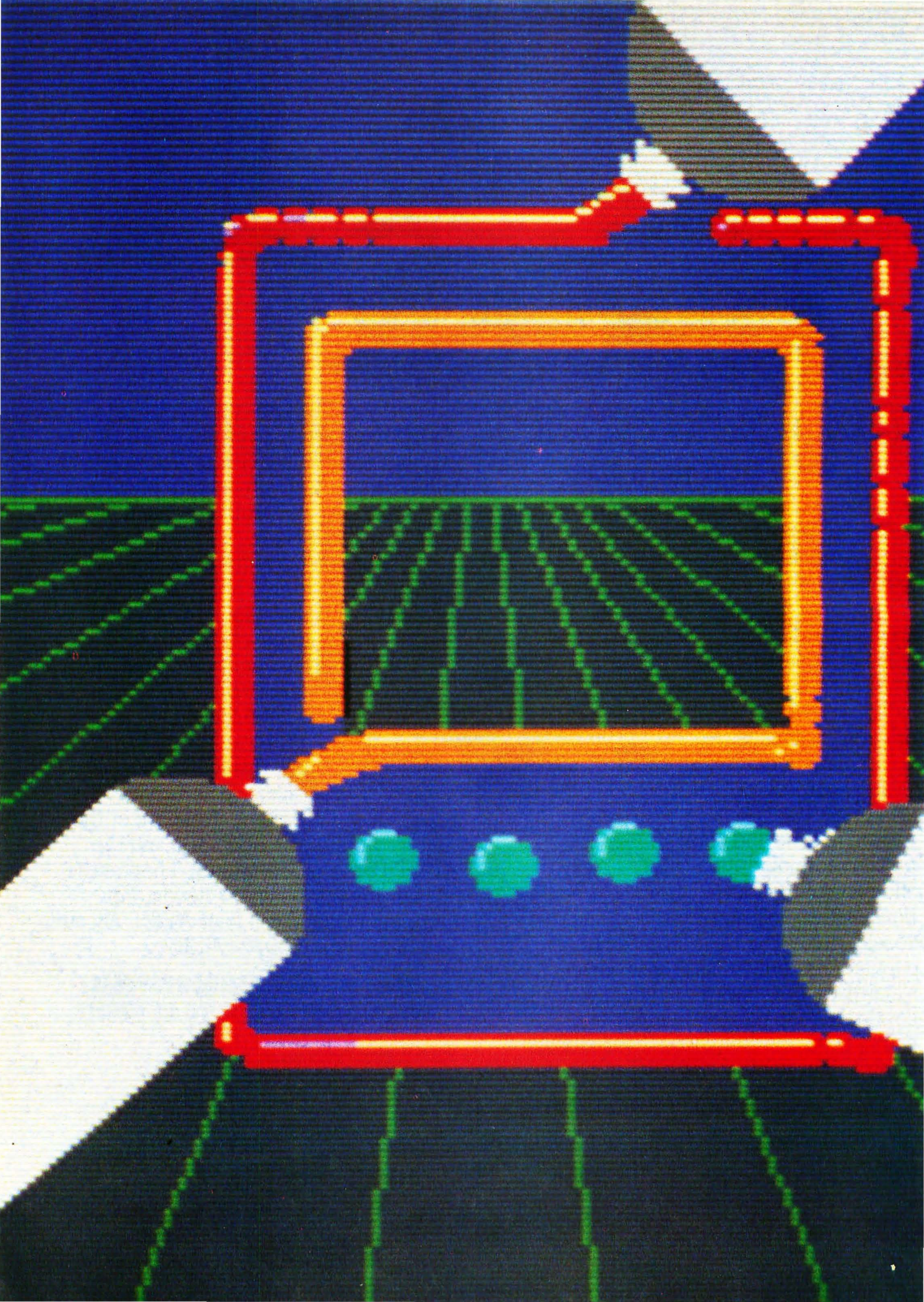

Features

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THEY MULTIPLY LIKE ZUCCHINI in a lush New England vegetable garden. Every time you acquire a new application, you use one or two of them for backup and others for data. You smoke or drink around them, use a ballpoint pen to write on them, or leave them lying around without their jackets at your peril. They clutter up your work area and are a nightmare to catalog and store. But those of us who grew up on micros that stored data on cassette tapes could not now live, for all their bother, without floppy disks.

The funny name—floppy disk—was coined to differentiate the flexible Mylar plastic disks from the rigid metal platters used in fixed-disk systems. The 5¼-inch disks have become ubiquitous to the point that 3½-inch microfloppy disks, unquestionably a better idea, have been slow to catch on.

This month, BYTE offers an unusual look at floppy disks. With rare electron microscope photographs, you'll see a floppy disk as never before and discover that smooth is a relative term. To complement these photographs, Robert Rodina examines a variety of name-brand disks in search of a clear victor in quality. And Thomas Sterling examines a new technique for detecting and correcting disk read/write errors. Lester Thompson finishes up with an exploration of the evolution of floppy-disk formats, those electronic road maps used by the disk operating system to place and locate information on the disk.

Disk technology, tried and true, yields to the new software genre known as outline processors in a Product Preview; West Coast Bureau Chief Ezra Shapiro examines KAMAS, the Knowledge And Mind Amplification System. A program for Z80-based computers, KAMAS is both a tree-structured, menu-driven outline processor and a programming language. Complicated, idiosyncratic, and difficult to learn, this threaded-code system is nevertheless a flexible and powerful addition to the long-neglected Z80 software library.

Steve Ciarcia descends into the Circuit Cellar to build a power monitor that you can use to measure the electricity consumed by your household appliances or scientific/industrial equipment. The power monitor accepts the attachment of up to five appliances. Then the monitor feeds a pulse for each kilowatt-second passing through it into your personal computer. A BASIC program stores this information and calculates energy use and cost.

There are several interesting ways to discern patterns in large information groups, including factor analysis and multiple regression. Rob Spencer explores an equally useful technique called cluster analysis and offers a simple BASIC program to recognize patterns in varying groups of data.

For the microcomputerist thinking about tackling a major programming project, we offer a detailed examination of the components and life cycle of a large software project. William Appelbe and Alex Pournelle outline the steps in the process from requirements analysis, specification, and design to coding, testing, and maintenance.

Steve Hendrix concludes his two-part examination of the 65816 microprocessor with a look at the hardware. The similarity of this new device to the 6502 will ensure that many new upgrades will be forthcoming shortly. Maybe the 65816 will extend the lifetime of the 6502, adding luster to an already spectacular career.

—*G. Michael Vose, Senior Technical Editor, Features*

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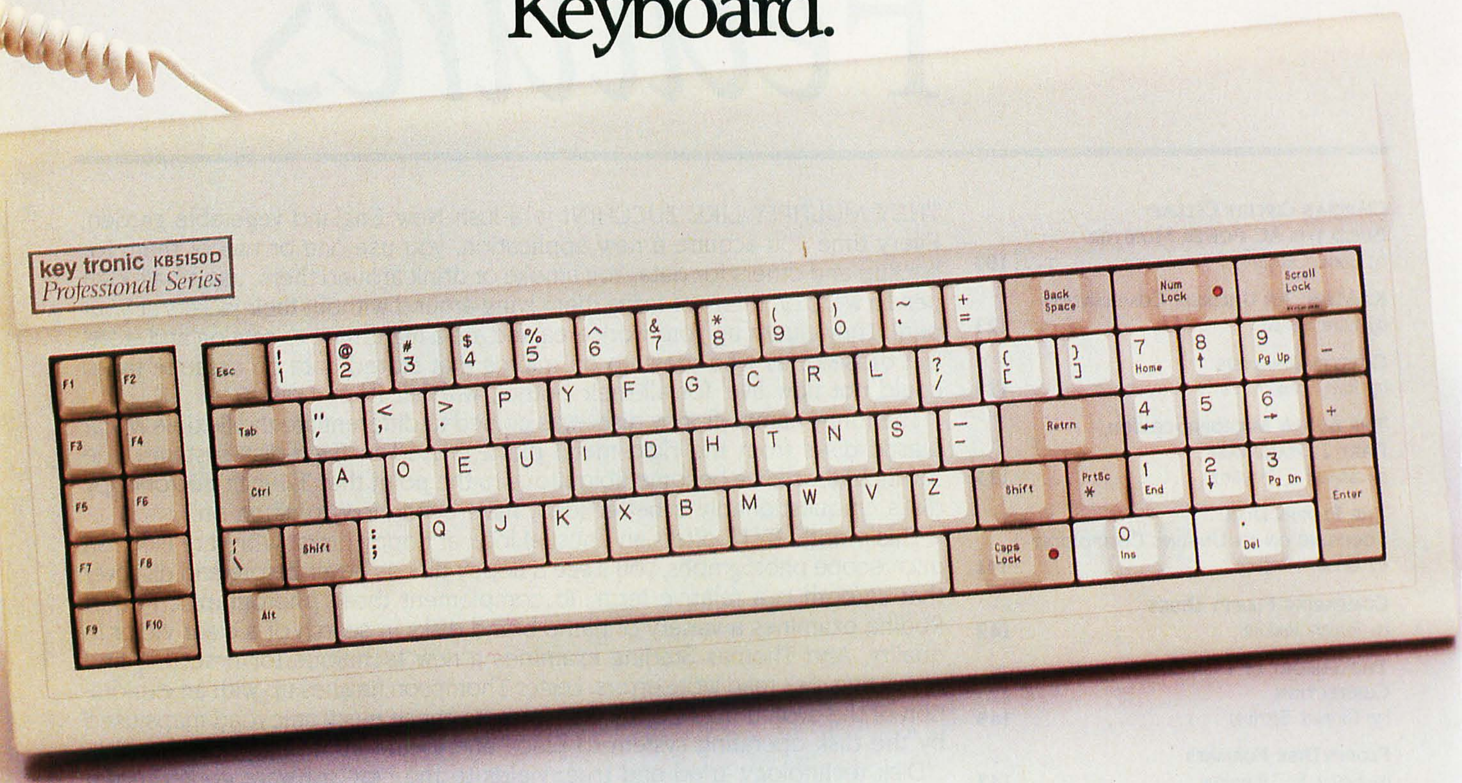

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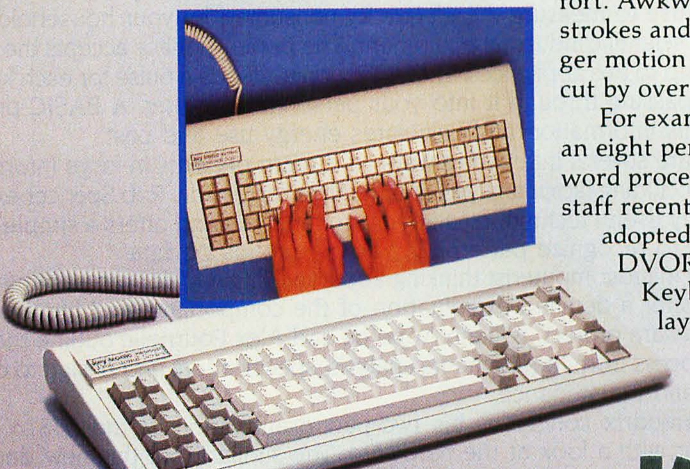

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CIARCIA'S CIRCUIT CELLAR

BUILD THE AC POWER MONITOR

BY STEVE CIARCIA

Your computer can measure electrical power consumption

I recently saw a commercial on television for the local power utility. I don't remember the exact details, but it compared the cost of certain commodities in the early 1900s with today's cost. Almost without exception, costs have increased. The only continuing bargain mentioned was electric power. A kilowatt-hour of electricity is still about a dime after 70 years of inflation. Unfortunately, this is little consolation when all these cheap kilowatt-hours add up to a $300 monthly electric bill.

While discussing utility costs with a friend, she mentioned that her electric bill averaged $56 a month. We each have electric stoves and oil hot-water heating. I assumed that her extra use of the stove, dishwasher, and washing machine, for a family of four, would more than offset all my gadgets in a house with only two occupants. Thus, my average bill should be about the same.

Was I wrong! I looked at my electric bills and determined that my power usage during the same period averaged $175 a month. Was the difference in our life-styles so significant, or could there be some hidden power-consuming devices that I didn't normally consider? It was time for a little analysis of the situation.

Lighting is the most obvious power usage in the home, and this was my first consideration. Unlike most homes, I always have a few lights on 24 hours a day. I hate searching in the dark for light switches, so I leave lights on in strategic locations. Together, they amount to perhaps 200 watts (W).

My office lighting is also a consideration. Generally speaking, if I'm in the house, I'm either asleep or working in the Circuit Cellar. Most of my power consumption occurs there: 12 ceiling lights (@ 75 W), six fluorescent tubes (@ 40 W), two table lamps (@ 150 W), and one floor lamp (five @ 40 W). That's 1640 W of lights. But that's only part of the story. With my computer equipment, copier, and monitors, I must be using 3000 to 5000 W.

The first reaction might be to pull the plugs. Fortunately, most of my real power consumption is not constant duty cycle. Logic suggests that the copier, for instance, will consume less power in standby mode between copies than when the heaters and drying fans are on as it makes copies. Similarly, while I have an oil-heating system like my friend's, mine has four zones instead of one, and they do not necessarily operate at the same time.

Given the intermittent but heavy power demand of the heating system; the outside floodlights; the copier; and about 10 other

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. He is the author of several books about electronics. You can write to him at POB 582, *Glastonbury,* CT 06033.

pumps, heaters, and motors around the house, it is no wonder that my electric bill is higher than hers. Unfortunately, there is no easy way to determine power consumption of specific electrical appliances, especially those that exhibit dynamic load changes.

Hundreds of articles have been written using the words energy management and conservation, but rarely do they go into the actual measurement of the kilowatt-hours used by an appliance. Perhaps power monitoring is such a trivial subject that no one pays much attention to it. In those cases where such information is required, the expensive data-acquisition equipment required is considered a necessary evil.

Have you ever asked yourself, "I wonder how much this costs to run?" This can be in reference to an air con-

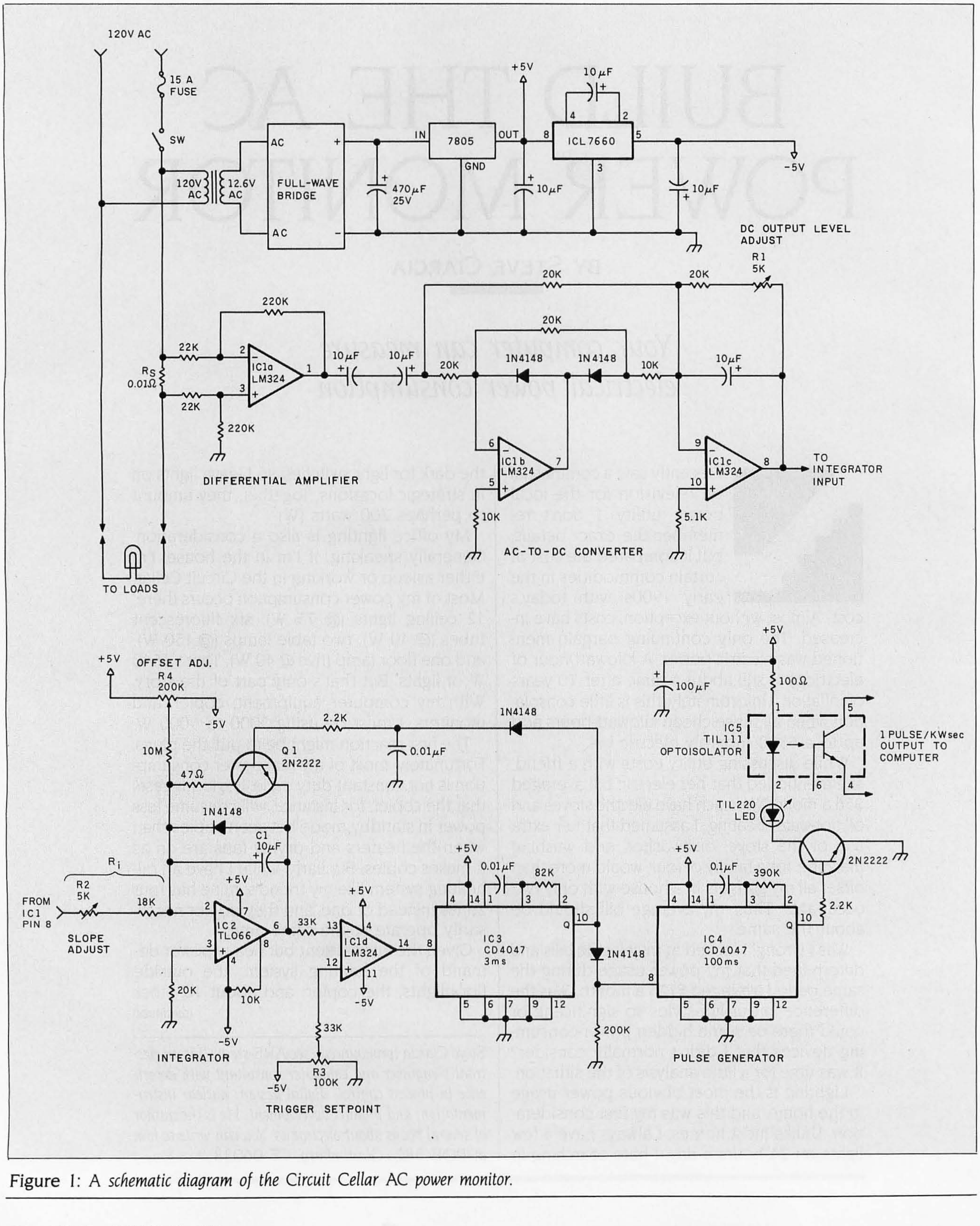

Figure 1: *A schematic diagram of the Circuit Cellar AC power monitor.*

ditioner, the pumps on the solar-heating system you are designing, or even your computer system. Have you heard that running a large air conditioner for a short period of time is supposed to be more efficient than a small one for a long time and wanted to prove it?

I decided to find a solution.

How Is Power Monitored?

Power is measured in watts. Disregarding power factors and dealing in general terms, watts equal voltage times current in most situations. If you have an electric heater that lists its power rating at 1320 W, it would draw 11 amperes (A) of current at 120 volts (V) AC. (If the voltage were lowered to 110 V AC, the same resistive element would consume only 1109 W. This is why power companies reduce voltage during periods of heavy usage.) Similarly, at 120 V AC, a 100-W bulb corresponds to a current of 0.8333 A.

The power company bills you for power usage based on the amount of power (kilowatts or kW) that you use over a given period of time (hours). Collectively, the expression is kilowatt-hour (kWhr), which means 1000 W of power used for one hour. In the case of a 100-W light bulb on for one hour, this would be 0.1 kWhr. If the light were on for a half hour, it would be 0.05 kWhr.

The power company charges by the kilowatt-hour. A typical cost is about 10 cents per kWhr (in central Connecticut, the cost is $.08902). The 100-W bulb on for one hour would therefore cost about a cent. More power hungry devices such as the heater would take 13.2 cents an hour to run.

Unfortunately, it's difficult to calculate the true operating costs when you factor duty cycle into the calculation. Once the heater is up to temperature, a thermostat causes it to cycle on and off to maintain the room at a constant temperature. Since this is less than a 100 percent duty cycle, it costs less than 13.2 cents per hour to run. But how much less?

One way to measure it is to sit there and hit a stopwatch or in some way automatically record every time the heater goes on and off and total these periods into a kilowatt-hour value. This is much the same way that the kilowatt-hour meter on the side of your house works. Basically, it is nothing more than a motor whose speed is proportional to the power passing through it. Its shaft is connected to a series of gears and dial indicators that register how many revolutions the motor has made. It turns very slowly when only a few lights are on and very quickly when heavy-current items such as electric stoves are turned on. In my case, I think it's been turning pretty fast.

The one advantage of the mechanical kilowatt-hour meter is that it is a true integrating indicator. Assuming that the voltage remains constant, if the current to a load doubles (such as a second element in the heater turning on concurrently with the first), the meter turns twice as fast. To equal this using our stopwatch and clipboard, we would have to record current value as well as time.

Most commercial electronic kilowatt-hour monitors measure time, voltage, and current. Many also employ a computing capability to derive the results. Conceivably, we could strive to duplicate these devices. Since most of the people reading BYTE already have a computer that could record time and perform the calculations, we only need to measure voltage and current. It must be remembered that voltage and current are analog parameters that must be converted to digital values if a computer is involved. Typically, acquiring this data involves using a 10- to 12-bit analog-to-digital (A/D) converter. It must have enough dynamic range to read the high voltages across the load as well as the millivolt shunt indications in series with the load.

The expense associated with such an interface has generally limited discussion of power-consumption monitors. For me to produce a project that is both cost-effective and universally applicable, I have to consider alternative means of measuring time, current, and voltage to compute energy use.

Computing Power Consumption

The first consideration is voltage. Nominally 120 V AC, the AC power-line voltage averages between 115 and 125 V AC in most places. If I arbitrarily assume that the voltage is a constant 120 V AC, I would have a worst-case error of only ±4 percent should it vary within those limits.

With that as a prerequisite, determining the power consumed is merely a matter of integrating the load current over a given period of time and calculating watts versus time. Such refined data, however more easily obtained, is no less easily conveyed to a computer than the original data variables themselves. Communicating 0.0830 kWhr to the computer through a serial or parallel interface can be just as involved as building an A/D converter.

The Circuit Cellar power monitor fits in a power strip and has a single-bit optoisolated output that can be attached to your computer.

The alternative is to make time one of the variables in the calculation. Rather than measuring the power consumed between fixed starting and ending points and totaling and reducing the data to a value such as 0.765 kWhr, I'll describe the amount of power used in smaller, more easily defined increments.

For example, 1 kWhr is the same as 60 kilowatt-minutes (kWmin) or 3600 kilowatt-seconds (kWsec). A 100-W bulb on for 6 minutes consumes 0.01 kWhr, 0.6 kWmin, or 36 kWsec, depending on how you want to record it. The 0.765-kWhr value mentioned earlier is the same as 2754 kWsec.

To input the number 0.765 into the computer requires many parallel lines or a serial interface. Communicating 2754 kWsec, however, requires only one wire (plus ground) between the power monitor and the computer if these smaller increments are communicated in real time. We can let the computer count the total kilowatt-seconds and do the calculations.

The cost-effective solution is to design a power monitor that generates a pulse every time the load uses 1 kWsec. During the 6 minutes a 100-W bulb is on, pulses will be occurring at a rate of one every 10 seconds (a total of 36 pulses). Total power cost is then computed by dividing the number of accumulated pulses by 3600 to get kilowatt-hours and then multiplying the result by the cost per kilowatt-hour in your area.

The AC Power Monitor

The Circuit Cellar power monitor is designed to perform as I've described. It fits inside a power strip and has a single-bit optoisolated output that can be attached to any available input bit on your computer. A convenient choice is a bit on the parallel printer port. Output from the power monitor is a 100-millisecond (ms) pulse every kilowatt-second consumed by the load. For a 250-W load, the pulse rate is once every 4 seconds. At 1000 W, pulses occur once every sec-

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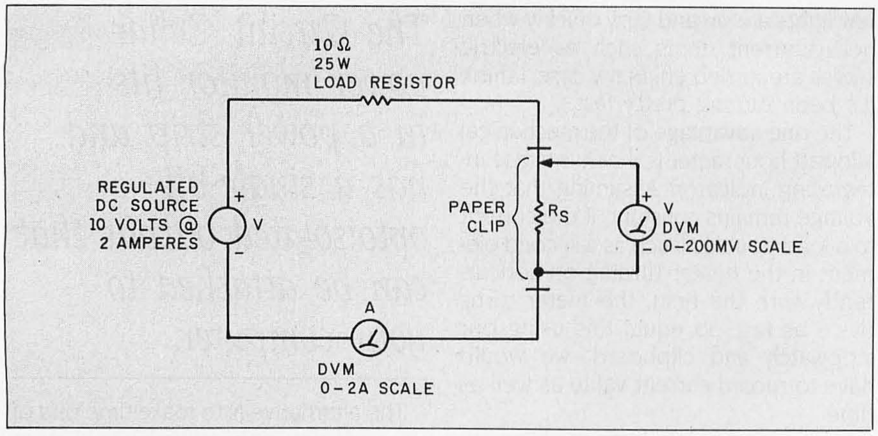

Figure 2: *Calibrating the paper clip.*

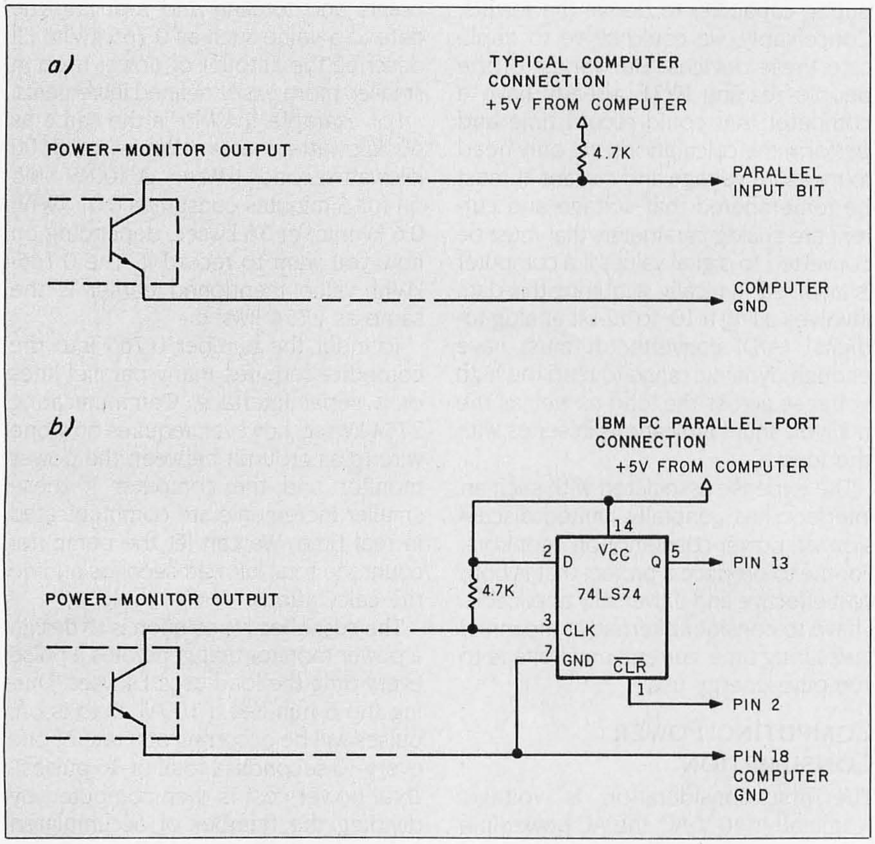

Figure 3: *The connection between the computer and the power monitor: (a) shows the usual connecting circuit; (b) shows the circuit needed to connect the monitor to an* IBM PC.

ond. As the load changes (motors and heaters cycling on and off), the pulse rate increases or decreases proportionally.

The monitoring range of the power monitor is 30 to 1800 W in the prototype configuration described. The maximum power that can be monitored is limited by the 15-A circuit breaker on the power strip rather than by the circuit design. In my opinion, the circuit as shown should be equally accurate to loads of 3000 W or more. I've included host-computer software that totals and displays the data generated by the power monitor.

Please remember that part of the Circuit Cellar power monitor attaches directly to the power line, which means a shock hazard exists. Only experienced individuals should attempt to build this device. Use extreme care while testing the circuit on line. If any connection is made to a computer, it should be made only through the optoisolated output provided. Do not connect the power monitor's +5-V supply to the 4.7k-ohm pull-up resistor on the monitor's output to the computer!

The circuitry of the power monitor (see figure 1) is relatively straightforward. It is basically an AC measuring device with the addition of integrating and pulse-generating sections.

While not generally of major concern, the power supply for the power monitor should be carefully considered. The power monitor requires both a positive and negative 5-V supply to accommodate the bipolar levels in the circuit. While the circuit itself takes only 4 milliamperes (another 20 when the LEDs [light-emitting diodes] fire for 100 ms) to run, the voltages must be regulated.

The power-supply circuit I have illustrated uses a single 12.6-V AC transformer winding to produce a regulated +5 V. An ICL7660 provides the –5 V. While other inverter circuits abound, if you don't have an ICL7660, don't substitute an alternate inverter circuit because it may not have sufficient regulation. Instead, substitute a 24-V AC transformer and construct a dual-polarity supply incorporating two regulators such as the 7805 and 7905. The approach I took, using a small transformer from Radio Shack (catalog #273-1385) and a DC-to-DC converter, was chosen merely to fit into the power-strip enclosure. Since many of you might want to build it the same way, that is the way I've documented.

MEASURING CURRENT

The most critical aspect of the monitor is the current-measuring section: Rs and IC1a. A precisely calibrated current-sensing resistor (also called a current-measuring shunt resistor), Rs, is placed in series between the voltage source and the load. As current flows through the wires, a voltage is produced across Rs proportional to the current flowing through it, according to the relation E=I×R, that is, voltage equals current times resistance.

The shunt resistance, in this case 0.01 ohm, is low to reduce internal power dissipation, which would change the temperature and cause errors. A current through Rs of 1 A produces 10 millivolts (mV), while a 10-A current produces 0.1 V.

Before you say that you don't have a 0.01-ohm shunt lying around or a meter that can measure 0.01 ohm, let's derive the proper resistance using more easily measured values such as voltage and current.

The shunt resistor is most conveniently incorporated as a piece of connecting wire in the path between source and

Part of the power monitor attaches directly to the power line, which means a shock hazard exists. Only experienced individuals should attempt to build it and extreme care should be used.

load. Since it has to carry 10 to 15 A, it must be fairly thick wire. The #12 copper wire, which is used to connect the receptacles and the wall outlet, has too little resistance. It would take about a foot of copper wire to equal 0.01 ohm. An easily obtained high-resistance material is steel, and a convenient source in the proper form is a jumbo paper clip. (Would I lie to you?) About 2 inches of a paper clip is 0.01 ohm.

Proper use of the paper clip, however, requires calibration using the circuit shown in figure 2. First, a load resistor and the paper clip are connected in series to a regulated power supply. A piece of #22-gauge wire is soldered near one end of the paper clip. With an ammeter—preferably a DVM (digital voltmeter)—connected in series with these items, adjust the power-supply voltage to approximately 1 A. The absolute value is unimportant, but record the meter reading exactly (perhaps it was 1.104 A).

Next, without changing the voltage setting, remove the meter and reconnect the circuit so that the same current is flowing through the shunt. With the DVM set on the DC millivolt scale and one probe connected to the wire previously soldered to the paper clip, move the other probe along the paper clip until you read a voltage corresponding to the current you recorded, times 0.01 (about 10 mV). If that number were 1.104 A, you would be looking for 11.04 mV. At the point on the paper clip where you get the correct value, carefully solder the second sensing wire, as shown in photo 1. Let it cool and recheck your calibration. You may have to move the wire a millimeter or two in either direction.

When the sensing resistor is installed, the two sensing wires are connected to IC1a. This op amp is configured as a times 10 gain, inverting, differential amplifier. With a 100-W load plugged into the power monitor, the output of IC1a should be 0.8333 × 0.01 × 10, or 83.33 mV AC.

Next, the AC output from IC1a is converted to DC. IC1b and 1c are configured as an AC-to-DC converter that, unlike diodes alone, will work in the millivolt range. The R1 adjustment potentiometer is used to set the output of the converter to a DC value equal to the AC RMS (root mean square) voltage input to the converter. If the input is 0.973 V AC from IC1a, the output of IC1c is set at 0.973 V DC.

The output of the DC converter is connected to an integrator, IC2, which converts current and time to kilowatt-seconds. IC2 is a TL066-type low-power, high-impedance op amp. (Only this or a similarly rated op amp, such as an ICL7611, should be used if you want accuracy while measuring low-wattage

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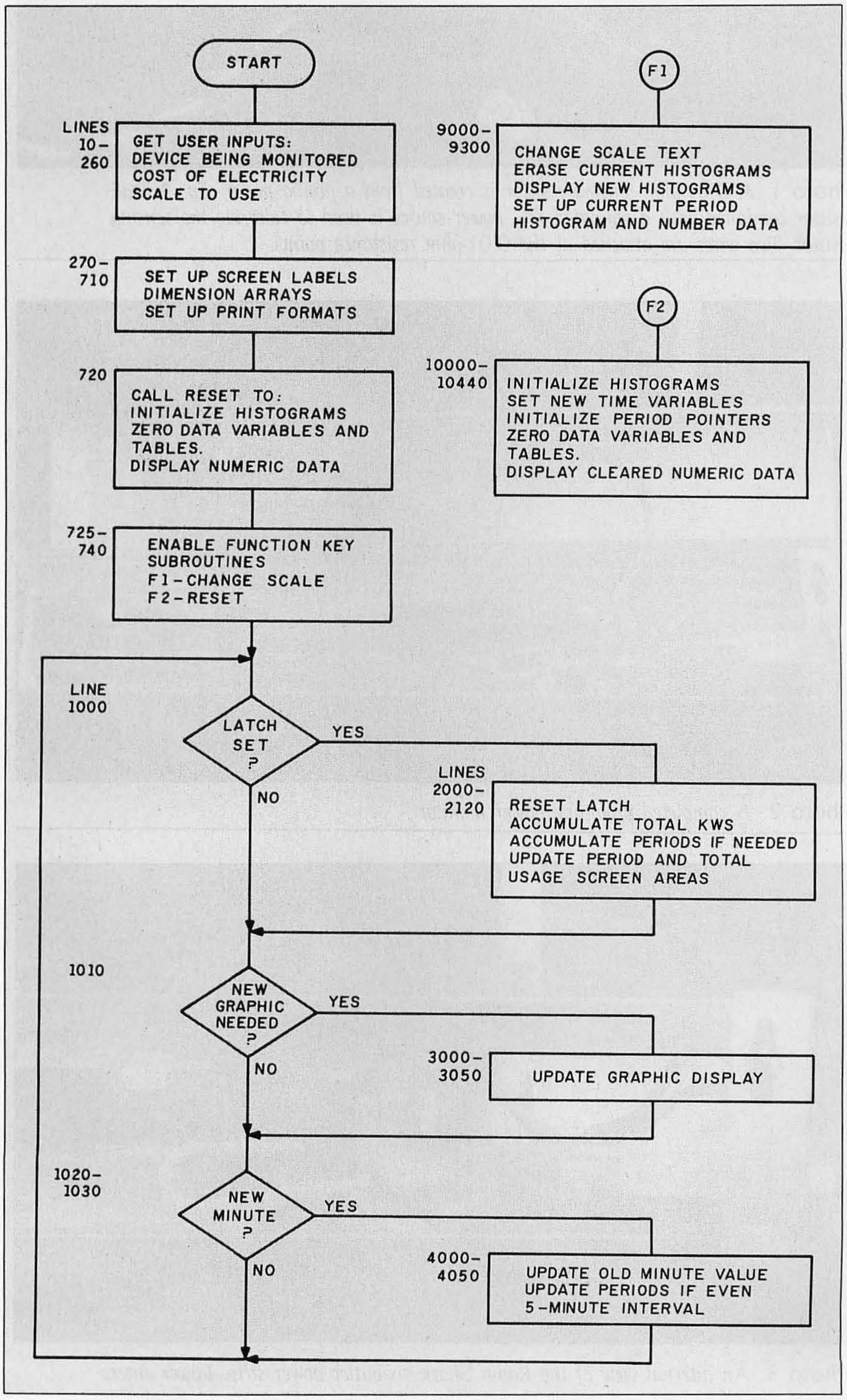


Figure 4: *A flowchart of listing* 1.

loads.) It is configured as an integrator whose output level is defined as

$$Vo = -(Vi)(T)/(Ri)(C)$$

where Vi is the voltage from IC1 pin 8, T is time, Ri is R2 plus 18 kilohms, and C is essentially C1.

The integration cycle starts after discharge of the capacitor. Then, depending upon the positive level applied to the integrator, it ramps toward negative saturation. A 1000-W load provides an input voltage that causes the integrator to reach −4 V in exactly 1 second. IC1d, configured as a voltage comparator, senses when it reaches −4 V and triggers one-shot IC3 when it occurs. IC3's output, set for 3 ms, turns on transistor Q1, discharging the integrating capacitor C1 through a 47-ohm resistor. It also fires a second, longer one-shot (IC4) that signals the computer through an optoisolated connection that 1 kWsec has been consumed. At lower currents, the input to the integrator is less, and it takes longer for it to reach −4 V (a 100-W load takes 10 seconds, for example).

The integrator can also be used with intermittent loads such as a thermostatically controlled heater or a level-activated pump. When a load is seen by the power monitor, the integrator starts to climb toward the trigger value. If the load is suddenly removed, the integration voltage level remains constant for a relatively long period of time. If the load is resumed, the voltage level starts from the same point at which it left off. If the load is off for more than a few minutes, the charge gradually leaks off C1, and some portion of a kilowatt-second is lost. The purpose of offset adjustment R4 is to minimize this drift when no load is applied and to make sure that the drift is in a direction (away from −4 V) such that a false trigger will not occur.

The connection to the computer is through an LED optoisolator. Every time a kilowatt-second is detected by IC1d, IC4 is fired for 100 ms. Two LEDs are connected to its output: the optoisolator and one that serves as a visual indicator of power consumption. The collector and emitter leads of the optoisolator, IC5, are connected to the computer. The emitter is connected to ground while the collector is tied to +5 V (supplied from the computer) through a 4.7k-ohm resistor. The output at the collector is then tied directly to any available TTL (transistor-transistor logic) input line (an alternative approach using an IBM Personal Computer (PC) will be described later).

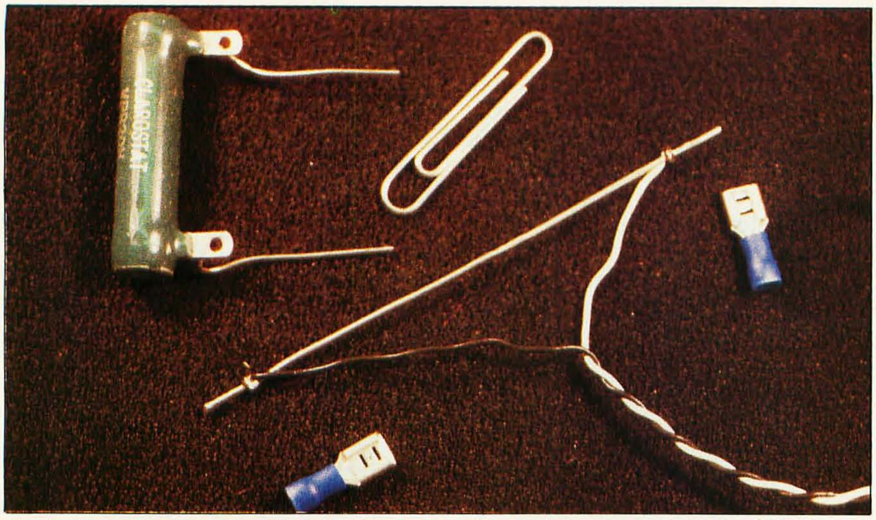


Photo 1: *A 0.01-ohm sensing resistor is created from a jumbo paper clip. A load resistor combined with a regulated DC power source is used to calibrate the sensing resistor. Two wires are attached at the 0.01-ohm resistance points.*

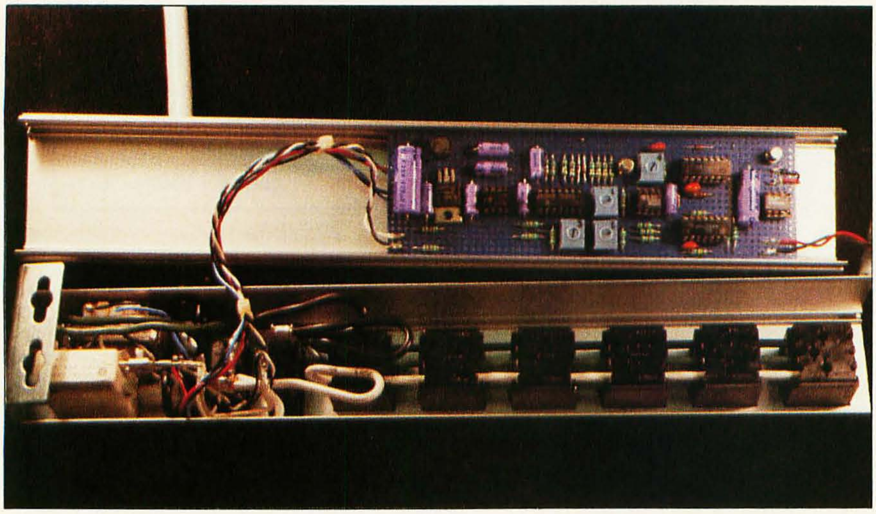


Photo 2: *A completed prototype power monitor.*

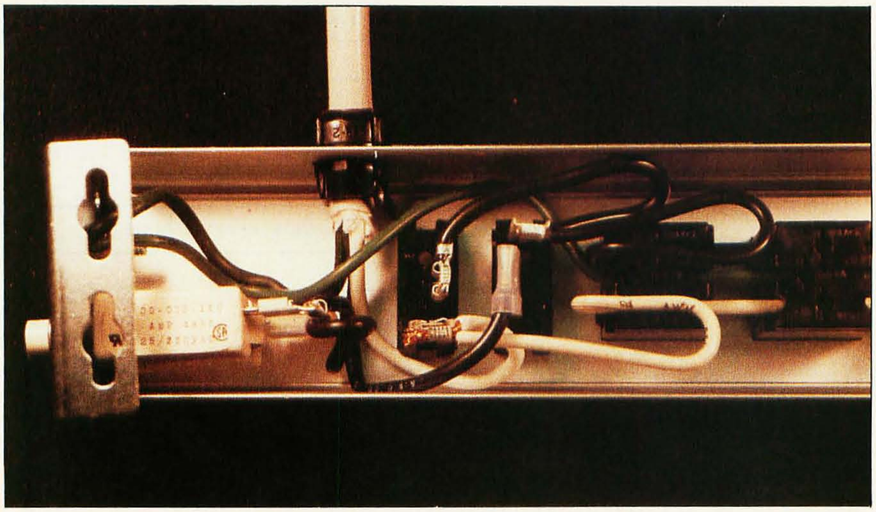


Photo 3: *An internal view of the Radio Shack six-outlet power strip. Power enters through the white cord and travels through the switch and a 15-A circuit breaker to the outlets.*

CONSTRUCTION AND CALIBRATION

Photo 2 shows the prototype power monitor that I built. The enclosure is a Radio Shack six-outlet power strip (catalog #61-2619A). It incorporates a 15-A circuit breaker, pilot light, power switch, and six receptacles.

Conversion to a power monitor is relatively straightforward. Following disassembly of the power strip, remove the black wire between the circuit breaker and the power switch; the wire is shown in photo 3. Replace it with the paper clip sensing resistor, as shown in photo 4. The paper clip should be insulated (heat-shrink tubing is good) to prevent short circuits.

I glued the power transformer next to the circuit breaker, as shown in photo 5, and installed the monitor LED next to the existing neon indicator. The rest of the circuit, shown in photo 6, was built on a 2- by 6-inch perforated board that slides into the rear cover. The entire unit snaps together to provide a convenient and safe prototype enclosure.

You can test and calibrate your power monitor in two ways: with a simulated load and with an actual load. Which method you choose depends on how accurately you have constructed your 0.01-ohm sensing resistor. If you are fairly confident that it is correct, simulated conditions will suffice. The alternative is to use some form of calibrated load that allows you to calibrate the entire power monitor, including the sensing resistor. Ultimately, you will need 83.3333 mV presented to the input of IC1a. Under actual operating conditions, this requires a 1000-W load.

Simulating this load is much easier. It is accomplished by disconnecting the sensing resistor and replacing it with a larger-value resistor, such as 47 ohms. With an additional series resistor, the combination is attached to the output of a low-voltage transformer. I took the same 12.6-V output transformer used in the power supply and varied the input to it with a Variac autotransformer. Using a DVM set for AC millivolts, the autotransformer is adjusted to produce 83.33 mV across the input sense points of IC1a.

Next, with the meter set for DC volts connected to IC1 pin 14 and ground, R1 is adjusted to get a reading of 0.8333 V DC.

An oscilloscope is needed for the next phase. The point of observation is IC2 pin 6 while the trigger point is either

(continued)

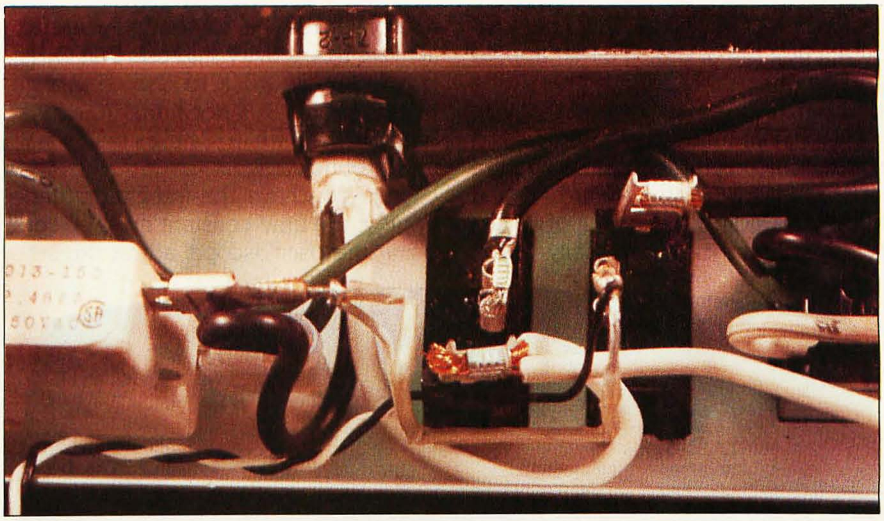


Photo 4: *The wire from the hot side of the breaker (black wire) to the switch is replaced with the paper clip sensing resistor. Notice how it is bent to fit the enclosure. It is insulated with heat-shrink tubing. The sensing wires (#22 black-and-white) are connected to the power-monitor electronics.*

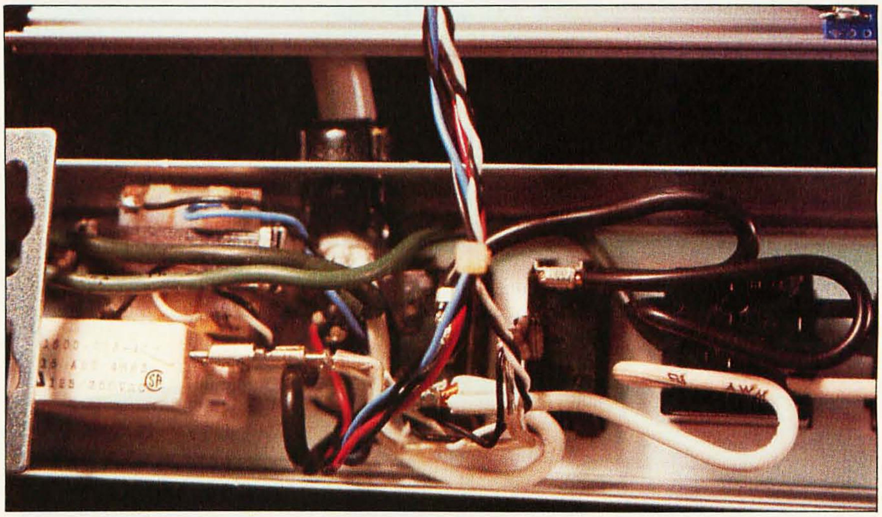


Photo 5: *A 12.6-V AC, 300-mA transformer is inserted and secured within the case next to the circuit breaker. Its output is also connected to the power-monitor electronics.*

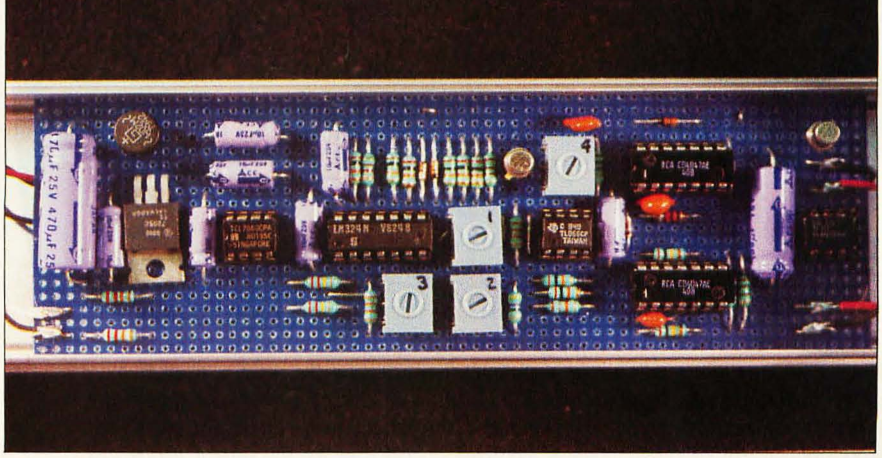
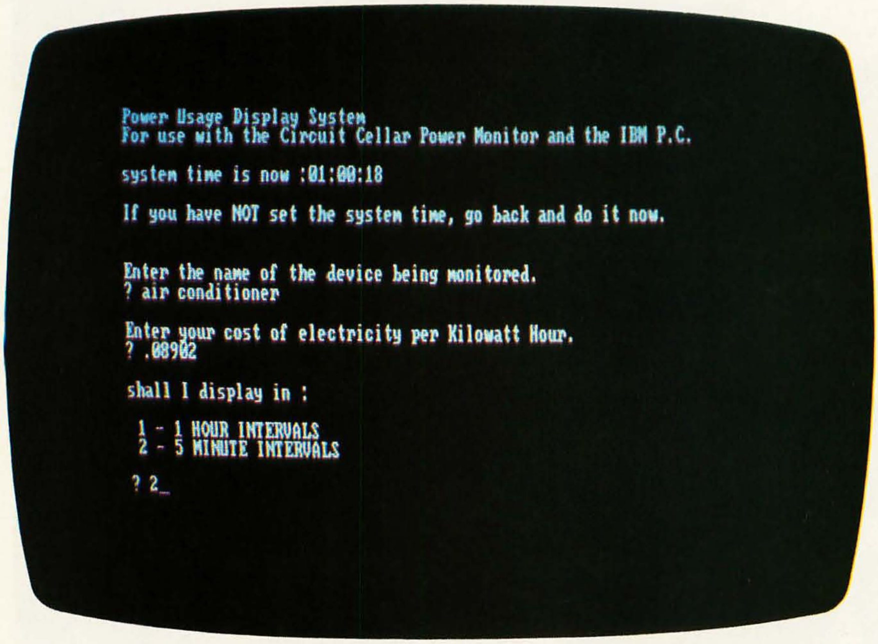


Photo 6: *A close-up of the power-monitor electronics.*

IC1 pin 7 or IC3 pin 10. The integrator output (IC2 pin 6) should either appear as a sawtooth waveform or be sitting somewhere between −4 and −5 V.

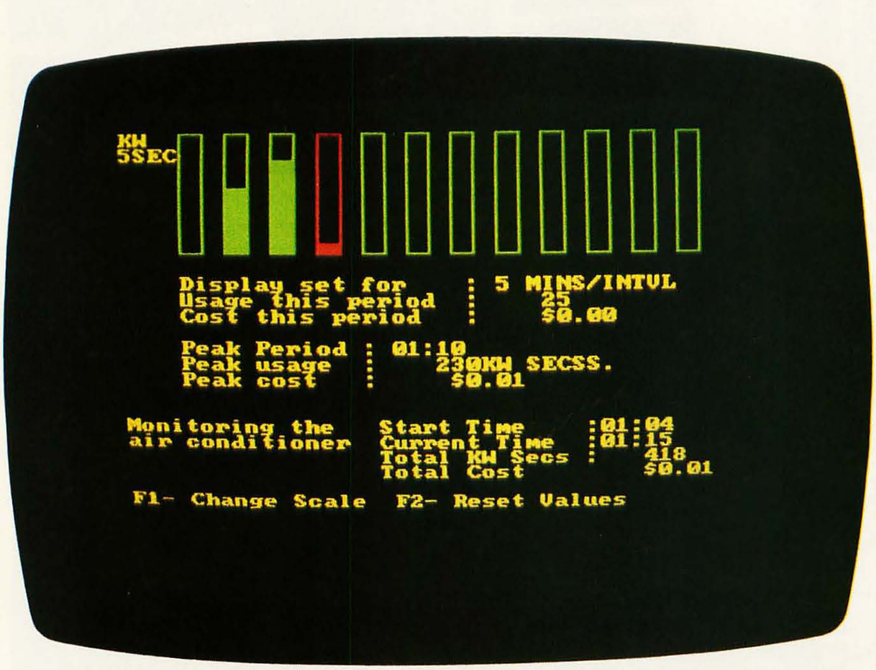
Using a clip lead, momentarily short out C1. The integrator output will return to 0 V and slowly ramp toward −5 V. If this occurs, adjust the setting of R3 until the integrator automatically resets and produces the sawtooth. Failure to achieve this activity suggests that Q1 is installed backward, IC1d is wired wrong, or one-shot IC3 is not firing (IC3 runs on + or −5 V while IC4 uses only +5 V and ground).

Once you have the integrator functioning, the time constant must be set. Using the oscilloscope, adjust the settings of R2 and R3 so that the output at IC2 pin 6 goes from 0 to −4 V in exactly a second each time it's reset.



```
Power Usage Display System
For use with the Circuit Cellar Power Monitor and the IBM P.C.

system time is now :01:00:18

If you have NOT set the system time, go back and do it now.


Enter the name of the device being monitored.
? air conditioner

Enter your cost of electricity per Kilowatt Hour.
? .08902

shall I display in :

 1 - 1 HOUR INTERVALS
 2 - 5 MINUTE INTERVALS

? 2_
```

Photo 7: *Power-monitor software initialization.*



```
KW
5SEC

    Display set for      : 5 MINS/INTVL
    Usage this period    :    25
    Cost this period     :    $0.00

    Peak Period : 01:10
    Peak usage  :     230KW SECSS.
    Peak cost   :     $0.01

Monitoring the     Start Time      :01:04
air conditioner    Current Time    :01:15
                   Total KW Secs  :     418
                   Total Cost           $0.01

F1- Change Scale  F2- Reset Values
```

Photo 8: *Monitoring software in operation, demonstrating the power consumed by an air conditioner over a predetermined interval. Time starts from left to right. In this example, each rectangle represents 5 minutes. The current time is indicated by the red block, and increasing consumption is registered in real time for the current period and for total elapsed time. After 15 minutes, $0.01 has been consumed.*

Finally, with the DVM on the integrator output, switch off the load or simulated input source and note the reading. It should be stationary and drop only a millivolt or so a second. Adjust R4, if necessary, to achieve this. If it continues to drift after adjustment, even if only a small amount, set R4 so that the drift is in a positive direction away from −4 V.

Turn the load back on. If everything is operating correctly, the monitor LED attached to Q2 should be blinking once per second. If not, check the one-shot to see if one of the LEDs is backward.

Provided that you get the blinking indicator, the testing is completed. You can test your power monitor by simply plugging various loads into it and watching the LED. Try a table lamp, then a toaster.

COMPUTER MONITORING

The whole purpose for the particular design employed in the Circuit Cellar power monitor is to make it easily attachable to any computer. Once connected, the computer adds the kilowatt-second pulses, plots a power-usage-versus-time display, and calculates the total kilowatt-hour cost during the usage period.

I consider the main emphasis of this article the production of the monitor, but the software is a significant component. To best illustrate how the functions are performed, I wrote the program entirely in BASIC, which is relatively easy to understand and more transportable between systems. I chose to use the IBM PC simply for convenience.

By using only BASIC and no machine-specific assembly language, I have had to incorporate one modification to the power monitor/computer interface that would not normally be required if I had used assembly language. Since BASIC is relatively slow, I can't be absolutely sure that the program will be through with its housekeeping chores and not miss a pulse if connected to a high-wattage load. (While I could have used TBASIC and the Trump Card described in the May and June Circuit Cellar articles to speed things up, there is some merit in describing less costly alternative solutions.) To eliminate the concern, a flip-flop is installed at the computer input. When the pulse occurs, the flip-flop is set and remains set after the pulse is gone. When the program reads the flip-flop, it resets it.

(continued)

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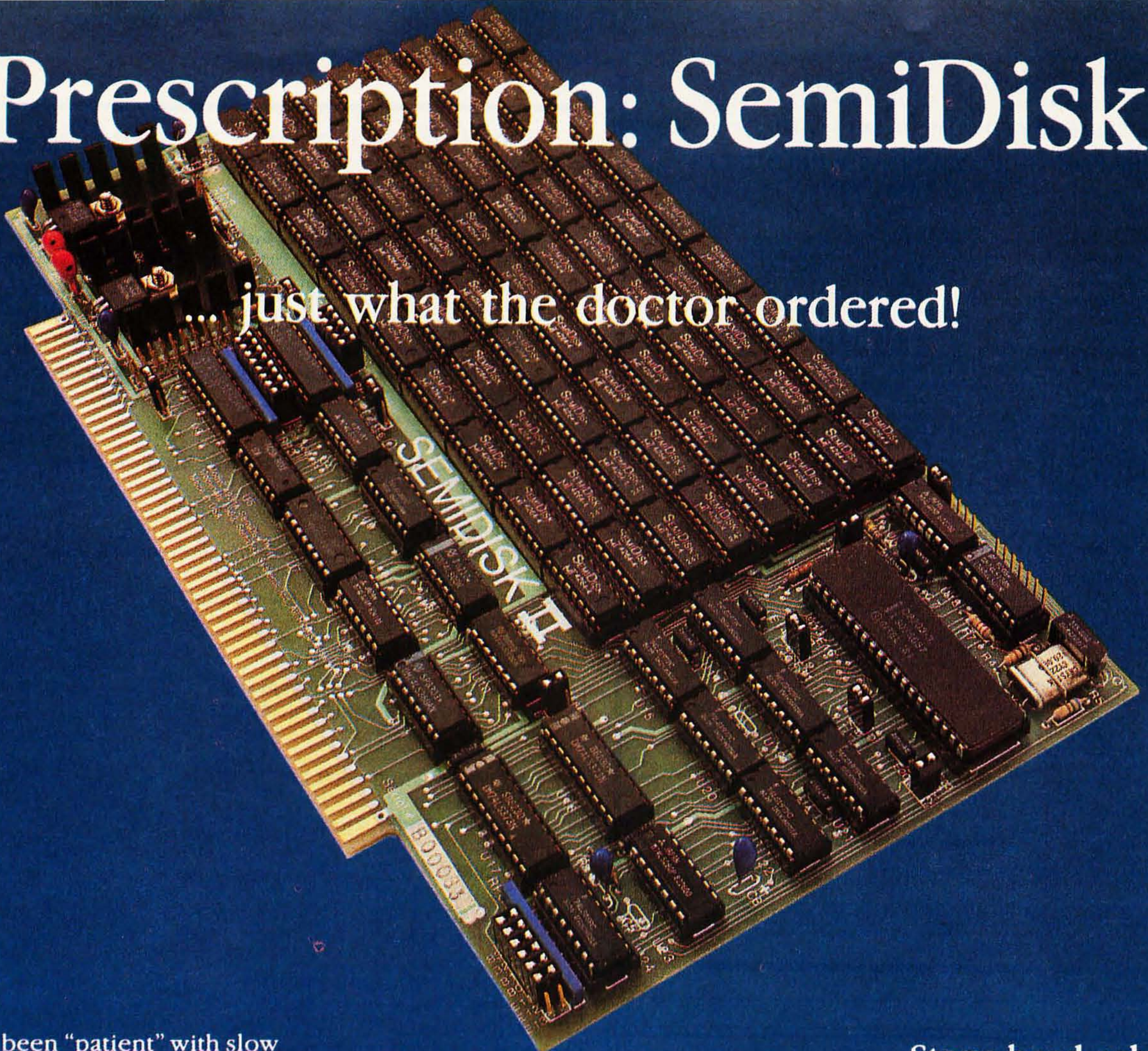

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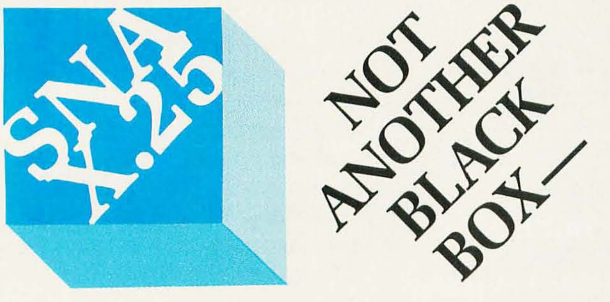

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Listing 1: *The source code for the power-usage display system.*

```
10 CLS
15 KEY OFF
20 WIDTH(80)
30 PRINT "Power Usage Display System"
40 PRINT "For use with the Circuit Cellar Power Monitor and the
   IBM P.C."
50 PRINT
60 PRINT "system time is now :";TIME$
70 PRINT
80 PRINT "If you have NOT set the system time, go back and do
   it now."
90 PRINT
100 PRINT
110 PRINT "Enter the name of the device being monitored."
120 INPUT P$
130 IF LEN(P$)>16 THEN P$=MID$(P$,1,16)
140 PRINT
150 PRINT "Enter your cost of electricity per Kilowatt Hour."
160 INPUT C
170 C=C/3600 :REM scale to KW seconds.
180 PRINT
190 PRINT "shall I display in  :"
200 PRINT
210 PRINT " 1 — 1 HOUR INTERVALS"
220 PRINT " 2 — 5 MINUTE INTERVALS "
230 PRINT
240 INPUT S
250 IF S=1 OR S=2 THEN 270
260 GOTO 180
270 REM set up the screen
280 CLS
290 SCREEN 1
300 COLOR 0,0
350 LOCATE 1,1
360 PRINT "KW";
370 LOCATE 2,1
380 IF S=1 THEN PRINT "MIN  ";
390 IF S=2 THEN PRINT "5SEC";
400 LOCATE 10,5
410 IF S=1 THEN PRINT "Display set for       : HOURS";
420 IF S=2 THEN PRINT "Display set for       : 5 MINS/INTVL";
430 LOCATE 11,5
440 PRINT "Usage this period   :";
450 LOCATE 12,5
460 PRINT "Cost this period    :";
470 LOCATE 14,5
480 PRINT "Peak Period   :";
490 LOCATE 15,5
500 PRINT "Peak usage    :";
510 LOCATE 16,5
520 PRINT "Peak cost     :";
530 LOCATE 19,18
540 PRINT "Start Time        :";
550 LOCATE 19,1
560 PRINT "Monitoring the";
570 LOCATE 20,18
580 PRINT "Current Time  :";
590 LOCATE 21,18
600 PRINT "Total KW Secs:";
610 LOCATE 20,1
620 PRINT P$;
630 LOCATE 22,18
640 PRINT "Total Cost      :";
650 LOCATE 24,1
660 PRINT "F1- Change Scale  F2- Reset Values";
700 DIM T(2,12),PK$(2),PU(2)
710 M$="$$####.##":N$="######"
720 GOSUB 10000
725 ON KEY(2) GOSUB 10000
727 KEY(2) ON
730 ON KEY(1) GOSUB 9000
740 KEY(1) ON
1000 IF (INP(&H3BD) AND 16) < >0 THEN GOSUB 2000
1010 IF T(S,PE)>PG THEN GOSUB 3000
1020 T$=MID$(TIME$,4,2)
1030 IF T$< >MO$ THEN GOSUB 4000
1040 GOTO 1000
2000 OUT &H3BC,1:OUT &H3BC,0
```

(continued)

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```
2010 A=A+1:PU=PU+1
2020 IF A/60 = INT(A/60)THEN T(1,PH)=T(1,PH)+1
2030 IF A/5  = INT(A/5) THEN T(2,PM)=T(2,PM)+1
2040 LOCATE 11,25
2050 PRINT USING N$;PU;
2060 LOCATE 12,25
2070 PRINT USING M$;PU*C
2080 LOCATE 21,33
2090 PRINT USING N$;A;
2100 LOCATE 22,32
2110 PRINT USING M$;A*C;
2120 RETURN
3000 PG=T(S,PE)
3010 DRAW "bm"+STR$(32+PE*24)+",60"
3020 FOR X=1 TO PG
3030 DRAW "c2 u1 r12 l12"
3040 NEXT X
3050 RETURN
4000 MO$=T$
4010 T=VAL(T$)
4020 IF T/5 = INT(T/5) THEN GOSUB 5000
4030 LOCATE 20,33
4040 PRINT MID$(TIME$,1,5)
4050 RETURN
5000 KEY (1) OFF
5003 KEY (2) OFF
5005 IF T(2,PM)*5<=PU(2) THEN 5030
5010 PU(2)=T(2,PM)*5
5020 PK$(2)=PS$
5030 MT=PM
5040 PM=PM+1
5050 IF PM>=12 THEN PM=0
5060 IF S=2 THEN PS$=MID$(TIME$,1,5)
5070 T(2,PM)=0
5080 IF MID$(TIME$,1,2)=HO$ THEN 5190
5090 HO$=MID$(TIME$,1,2)
5100 IF T(1,PH)*60<=PU(1) THEN 5130
5110 PU(1)=T(1,PH)*60
5120 PK$(2)=PS$
5130 PS$=MID$(TIME$,1,5)
5140 HT=PH
5150 PH=PH+1
5160 IF PH>=12 THEN PH=0
5170 T(1,PH)=0
5180 GOTO 5200
5190 IF S=1 THEN GOTO 5410
5200 PU=0
5210 IF S=1 THEN PE=PH:OP=HT:GOTO 5230
5220 PE=PM:OP=MT
5230 DRAW "bm"+STR$(32+OP*24)+",60"
5240 DRAW "c1 u60 r12 d60 l12"
5250 FOR X=1 TO T(S,OP)
5260 DRAW "u1 r12 l12"
5270 NEXT X
5280 DRAW "bm"+STR$(32+PE*24)+",60"
5290 FOR X=1 TO 12
5300 DRAW "c0 u60 r1 d60"
5310 NEXT X
5320 DRAW "l12 c2 u60 r12 d60 l12"
5325 PG=0
5330 LOCATE 14,19
5340 PRINT PK$(S);
5350 LOCATE 15,19
5360 PRINT USING N$;PU(S);
5370 LOCATE 15,25
5380 PRINT "KW SECS";
5390 LOCATE 16,19
5400 PRINT USING M$;PU(S)*C
5410 KEY (1) ON
5415 KEY (2) ON
5420 RETURN
9000 IF S=1 THEN S=2:GOTO 9020
9010 S=1
9020 LOCATE 10,25
9030 IF S=1 THEN PRINT "HOURS        ";:GOTO 9050
9040 PRINT " 5 MINS/INTVL";
9050 LOCATE 2,1
9060 IF S=1 THEN PRINT "MIN  ";:GOTO 9080
9070 PRINT "5SEC";
9080 FOR X=0 TO 11
```

(continued)

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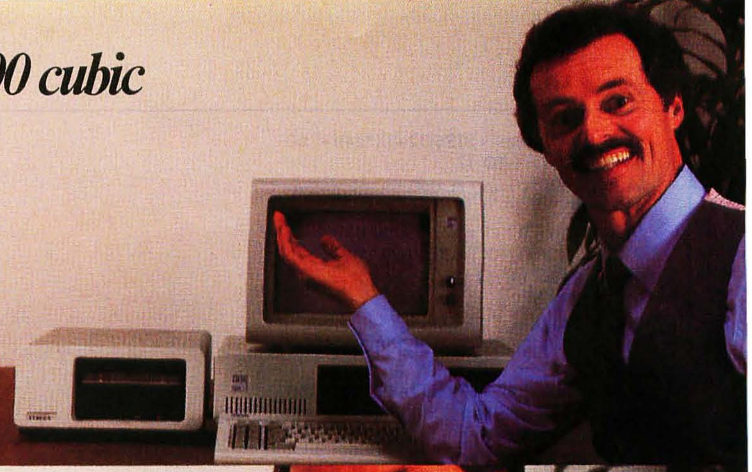

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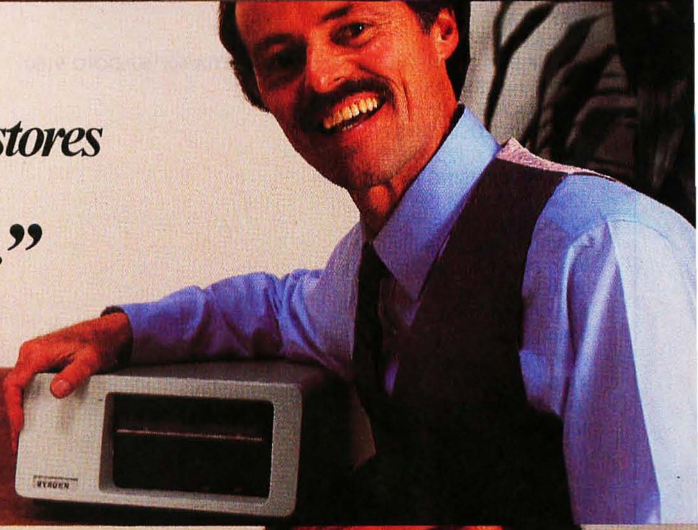

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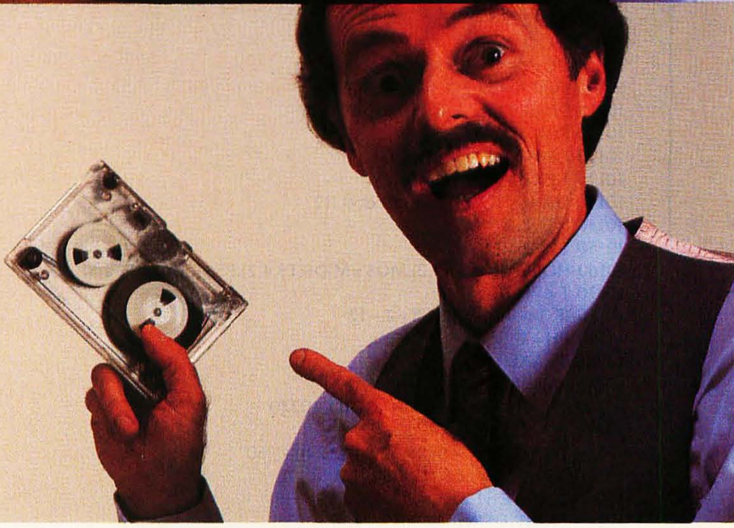

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```
9090 DRAW "bm"+STR$(32+(X*24))+",60"
9095 FOR Y=1 TO 12
9100 DRAW "c0 u60 r1 d60 "
9105 NEXT Y
9110 DRAW "l12 c1 u60 r12 d60 l12"
9120 FOR Y=1 TO T(S,X)
9130 DRAW "u1 r12 l12"
9140 NEXT Y
9150 NEXT X
9151 IF S=1 THEN PE=PH:GOTO 9153
9152 PE=PM
9153 DRAW "bm"+STR$(32+PE*24)+",60"
9154 DRAW "c2 u60 r12 d60 l12"
9155 PG=T(S,PE)
9156 FOR Y=1 TO PG
9157 DRAW "c2 u1 r12 l12"
9158 NEXT Y
9160 IF S=1 THEN PU=T(S,PE)*60+(A-INT(A/60)*60):GOTO 9180
9170 PU=T(S,PE)*5+(A-INT(A/5)*5)
9180 LOCATE 11,25
9190 PRINT USING N$;PU;
9200 LOCATE 12,25
9210 PRINT USING M$;C*PU
9220 LOCATE 14,19
9230 PRINT PK$(S);
9240 LOCATE 15,19
9250 PRINT USING N$;PU(S);
9260 LOCATE 15,25
9270 PRINT " KW SECS";
9280 LOCATE 16,19
9290 PRINT USING M$;PU(S)*C
9300 RETURN
10000 REM reset system routine
10005 OUT &H3BC,0
10010 FOR X=1 TO 2
10020 PK$(X)="START":PU(X)=0
10030 FOR Y=0 TO 11
10040 T(X,Y)=0
10050 NEXT Y
10060 NEXT X
10070 PG=0:PU=0:A=0
10100 FOR X=32 TO 300 STEP 24
10110 DRAW "bm"+STR$(X)+",60"
10120 FOR Y=1 TO 12
10122 DRAW "c0 u60 r1 d60"
10124 NEXT Y
10130 DRAW "l12 c1 u60 r12 d60 l12"
10140 NEXT X
10150 T$=TIME$
10160 HO$=MID$(T$,1,2):MO$=MID$(T$,4,2):PS$=MID$(T$,1,5)
10170 T=VAL(HO$)
10180 IF T>=12 THEN T=T-12
10190 PH=T
10200 T=VAL(MO$)
10210 PM=INT(T/5)
10220 IF S=1 THEN PE=PH:GOTO 10240
10230 PE=PM
10240 DRAW "bm"+STR$(32+(PE*24))+",60"
10250 DRAW "c2 u60 r12 d60 l12"
10260 LOCATE 11,25
10270 PRINT USING N$;PU;
10280 LOCATE 12,25
10290 PRINT USING M$;C*PU;
10300 LOCATE 14,19
10310 PRINT PK$(S)
10312 LOCATE 15,25
10314 PRINT " KW SECS."
10320 LOCATE 15,19
10330 PRINT USING N$;PU(S);
10340 LOCATE 16,19
10350 PRINT USING M$;PU(S)*C;
10360 LOCATE 19,33
10370 PRINT MID$(T$,1,5)
10380 LOCATE 20,33
10390 PRINT MID$(T$,1,5)
10400 LOCATE 21,33
10410 PRINT USING N$;A;
10420 LOCATE 22,32
10430 PRINT USING M$;C*A
10440 RETURN
```

Figure 3a is the usual connecting circuit between the power monitor and the computer; figure 3b is the specific circuit necessary for the IBM PC and the BASIC-only program described. Figure 4 is the flowchart of how the program works; listing 1 is the actual source code. Photo 7 shows the initialization of the software, and photo 8 shows the software in operation.

IN CONCLUSION

I think the Circuit Cellar power monitor is a step forward in energy management. We've discussed various methods for computerized control. Until now, however, we haven't had a cost-effective means to monitor activity on the power line or specifically determine power consumption.

While I haven't had my power monitor long, I've run a few tests that may be of interest to you. The monitor appears very linear and very accurate at higher loads. The range between 250 and 2000 W contains less than 1 percent of point error. At 100 W, the error is about 5 percent; about 10 percent at 50 W.

While I know there will be a great demand, no kit for the power monitor is available at the present time. The primary reason for this is packaging. Simply providing a PC board could lead to some potentially hazardous user installations. A safe, cost-effective enclosure must be provided before I feel that I can advocate direct power-line connection. Eventually, the power monitor will be available. In the meantime, you can continue to request the latest catalogs and circle the proper number on the bingo card.

NEXT MONTH

If you don't like to deal with tape measures, an ultrasonic range finder is on the agenda. ■

....

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles that appeared in BYTE from September 1977 through November 1978. *Volume* II covers December 1978 through June 1980. *Volume* III covers July 1980 through December 1981. *Volume* IV covers January 1982 through June 1983.

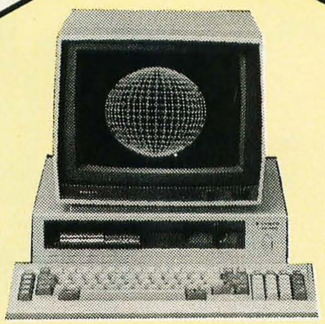
Special thanks to Bill Curlew for his software expertise.

To receive a complete list of Ciarcia's Circuit Cellar project kits available, circle 100 on the reader-service inquiry card at the back of the magazine.

#1 Rating
(Spreadsheet Configuration)
Auerbach's Index

". . . a terrific machine"
Microcomputing May 1984

". . . a great bargain"
Computers and Electronics May 1984



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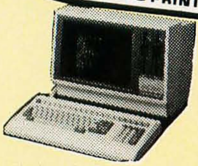

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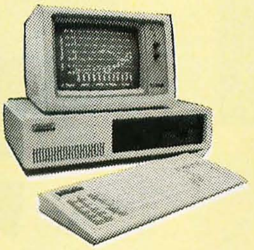

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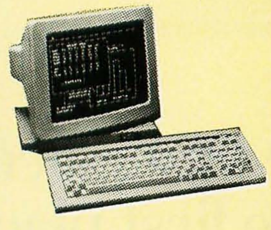

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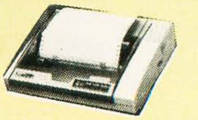

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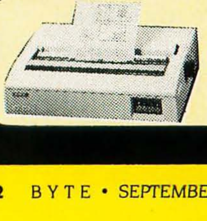

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KAMAS
An Unlikely Combination

Introducing outline processing and a FORTH-like language for Z80 systems

BY EZRA SHAPIRO

Editor's Note: The following is a BYTE product preview. It is not a review. We provide this advance look at this new product because we feel it is significant. A complete review will follow in a subsequent issue.

THE ACRONYM KAMAS stands for Knowledge And Mind Amplification System—a name that does little to explain what this unusual software package for Z80-based computers really does. On its most elementary level, KAMAS is a text-management program that lets you organize data into branching tree-like structures.

As a development tool, however, KAMAS is its own self-contained programming language. But unlike many integrated software products that claim varying degrees of programmability, KAMAS is an extensive threaded interpretive language that you can use to generate complex application programs that have nothing to do with word processing or related data manipulation. In fact, except for an 18K-byte kernel in Z80 assembly code, the program is written in itself.

KAMAS is a layered environment; that is, you can configure the command structure's degree of sophistication to match your needs—or your taste. The stock appearance of KAMAS is that of a menu-driven outline processor. Single-letter choices guide you through the process of creating what is essentially a text database organized around an outline. Using the built-in editors, you can enter a text chunk (ranging in size from a one-line title to a brief document) that serves as the top item of a hierarchy. If you give subsequent entries weight equal to the initial one, numerical order is the only ranking system among siblings and you'll have a collection of text items arranged much the same way as if you'd created them with a word-processing program.

KAMAS also lets you organize new entries as children of the parent item to construct the equivalent of an upside-down tree. This scheme shows each new child as a branch below its parent, ranked beneath it just as indented items in an outline are ranked below the more important items above them. The command structure of KAMAS provides for quick movement around the tree (for example, you can jump from one entry to its great-great-grandchild—four levels down—in one simple sequence). You can also move or copy text from one position on the tree to another, send output to the printer, and so on.

KAMAS's second layer is a macro language that lets you accomplish text and outline manipulation either by entering commands one by one from the keyboard or by creating files of command sequences that perform a series of operations when executed. On this level, KAMAS begins to function like a programming language.

From the second layer, you can invoke the two vocabularies that turn KAMAS into a full-blown language. The vocabulary for the third layer is a fully extensible threaded interpreter restricted to performing operations on data. It's possible for you to develop user-defined commands, even entire application programs, using KAMAS as you would any other programming language.

On the fourth level, KAMAS provides you with the tools to modify KAMAS itself. The difference between these two levels is functionally slight but tremendously significant. Were you to write an application program (a spreadsheet, say) using the commands available in the third vocabulary, you would load

(continued)

Ezra Shapiro is BYTE's West Coast bureau chief. He can be contacted at McGraw-Hill, 425 Battery Street, San Francisco, CA 94111.

AT A GLANCE

Name
KAMAS

Type
Outline processor and programming language

Additional Utilities Provided
Remote bulletin-board system (requires modem), debugger, memory dump, program utilities

Manufacturer
Compusophic Systems
POB 5549
Aloha, OR 97007
(503) 649-3765

Price
$175

Computer
Kaypro CP/M-80 and similar computers; other CP/M formats by request

Language
Z80 assembly and KAMAS

Documentation
64-page introduction and quick-reference guide; 668-page user's manual with tutorials, reference section, glossary, bibliography, and index; newsletter published regularly for registered owners

Audience
Writers and software developers

KAMAS and run your program; all of KAMAS's functionality would remain intact, and accessible if you wanted it. If you were to use the fourth-layer vocabulary, you could redefine KAMAS commands and strip KAMAS of any feature you did not find useful, leaving the shell of KAMAS as only an internal command-processing nucleus. Thus, on the third level, you can use KAMAS to write a program; on the fourth, KAMAS can become the program.

The first release of KAMAS, from Compusophic Systems of Aloha, Oregon, comes as a product for Kaypro computers. It's provided on Kaypro-format disks, and it assumes Kaypro terminal characteristics that emulate those of the Lear Siegler ADM 3A. Beyond that, KAMAS is a generic CP/M-80 program; if your computer can read the disk format and match the ADM 3A's video handling (well within the capabilities of a large proportion of CP/M machines), you can run KAMAS. The manufacturer will also provide copies of the program for other brands of Z80 computers on an order-by-order basis. A list price of $175 brings you the software, documentation that includes lengthy tutorials, and a subscription to a newsletter prepared by Compusophic that publishes tips for users and programs written in the KAMAS language.

THE FIRST LAYER

When you first run KAMAS, the prompt ROVE: appears after the sign-on message. The Rove mode is the command state in which you can enter single-letter mnemonics to manipulate the environment. It's largely based on menus; pressing the ? or the Return key (or any unimplemented character) produces a list of options. Then you can ask for more help or select a command.

When you enter a valid character, response is immediate. No carriage returns are required; you can move rapidly through a series of nested menus without pausing, merely by typing the appropriate characters.

In KAMAS terminology, every full tree system is called a topic. To extend the analogy, establishing a topic is like creating a tree trunk—the starting point for the development of a hierarchy. One topic comes on the distribution disk. Called Systopic, it contains help messages, error messages, and utilities written in the KAMAS language, all of which are linked to the operation of the program by a short KAMAS routine that runs automatically at start-up.

Initially, Rove mode drops you at the top level of Systopic. You can edit or reorganize every part of Systopic and you can add new material, but by doing so you run the risk of fouling up your safety net. You can, however, create additional topics for your own work by following through the topic-environment menu procedures accessed from Rove.

KAMAS can juggle up to 16 topics on line at a time, on as many physical drives as your operating system can handle. One of those topics must be Systopic, even if you're not working directly with it; KAMAS establishes context search paths that will seek Systopic for the messages it contains. The program crashes if it does not find Systopic.

Though you can move from one topic to another within KAMAS, you cannot transfer data among topics. The size of any one topic is limited solely by disk space; when you set up a new topic, KAMAS ask you to name it and specify its maximum size in K bytes. It makes sense to increase the size of a topic to handle your project plus some comfortable padding—if you use KAMAS to prepare a 100-page report and run out of room three pages from the end, you're in trouble.

Typing T (for Tenv, topic environment) at the ROVE: prompt produces a menu of selections that determine the overall topic environment; individual commands let you display system status, create new topics or kill old ones, list available topics, move from the currently selected topic to an alternate one, set the level of help provided, lock topics (set up a password to keep others from tampering with your material), or move to the expanded topic environment where you can work with macro commands instead of the Rove menus.

Once you have chosen your working (or "build") topic, you can use the two powerful editors in Rove to create text entries and rank them in the hierarchy. The first of these is an outline editor that lets you create single-line entries. The outline you produce becomes the primary structure for all further work. You can expand the outline; i.e., each item can become the heading for a lengthy block of text. You call up a second editor, the leaf editor, for this procedure.

KAMAS's editor is as capable as many word-processing packages on the market today. For Kaypro owners, the target audience for KAMAS, the editor's commands look like those of Perfect Writer, the word-processing program that was bundled with Kaypros for over a year. Compusophic promises either a utility on disk or a program listing in its news-

letter that will let you change the command set if you're not comfortable with Perfect Writer. Because KAMAS is programmable, you can write a similar utility—or a whole new editor—on your own if you're desperate for an immediate change.

You can restructure the outline by using the outline editor or by returning to the Rove mode. You can move any block you write, by itself or with its descendants, to another part of the outline by marking it, placing the cursor at the new location, and executing the Move command. After exiting from the editor, you can accomplish the same action by using Rove's Reorganize menu.

You can tailor your outline and text items for printout in a variety of styles using Rove's Format and Output options. You can suppress titles, subtitles, and indentations of the outline to make the collection of short text blocks that you've actually produced appear to be a standard document prepared with a traditional text-processing system.

Wandering around inside a topic is relatively easy. The outline editor provides the simplest mechanisms, but you can also use Rove menus. After typing G for Go at the ROVE: prompt, you have options for moving around in the outline. You can move either in a level-by-level path, following the hierarchical structure, or simply from one item to the next, top to bottom, jumping to the start of the next branch when you reach the last descendant of the prior one.

Three Go commands are worthy of special note. First is the Key command. KAMAS uses soundex algorithms throughout its location system. Soundex tables translate spellings to numerical codes that represent a limited number of phonetic equivalents; by using these tables in a text interpreter, the program can read variant spellings and determine the closest possible match. In KAMAS, a Key is the first part of the title of a stem (see table 1) and is the primary identifier of an item.

With the Go-Key command, you enter the name of an item, even one that is misspelled (within reason), and skip over any intervening items to the one you want. Next is the Go-Menu command, which gives you an alternative means of tracing your path down the hierarchy by replacing the Go movement commands with another sort of menu. When you wish to move down a branch, a menu shows you a numbered list of all items on the next level down and lets you choose one. Last is Go-Jex. Jex is KAMAS slang for job execution. When your cursor is located at an item that contains a KAMAS program, Jex loads and runs that program.

In Rove, KAMAS is not as visual a program as its competitors, ThinkTank and Framework (which run on computers capable of far more impressive screen handling than most Z80 machines). If you want to see where you are, you have to ask KAMAS for a display of one of its Show options. These include a screen dump of the current item, a focus to the current item that shows the path from the top of the topic to the item by indenting the titles of each succeeding branch, a view of the item that shows the titles of the outline elements both before and after it, and either simple or detailed displays of the outline that appears beneath the item.

The list of Query options is quite similar to the Show list; however, you can ask for similar displays of outline items far from your location by using the Query options. You also can display the text of a distant item without moving to it and then moving back to your current position. With Lookup, a related option, you request the location of an item either by its key or by performing a search for a character string you believe the item contains.

Because the outline editor does a better job of displaying titles than the Show and Query functions, the most effective use of KAMAS probably involves switching back and forth between it and Rove, depending on the type of operation you need to perform.

THE LANGUAGE

The KAMAS programming language is a threaded interpreter based on the model developed by Charles Moore and incorporated into FORTH and STOIC. Like the other members of this family, KAMAS comes as something of a shock to programmers accustomed to working with BASIC, Pascal, C, or any of the macro or query languages provided with database-management and spreadsheet programs.

A structured language provides a vocabulary of commands you use to create step-by-step procedures, along with user-defined commands you use to construct new commands that grow increasingly complex as you proceed from the top of a program to the bottom. The final line of a KAMAS program might not contain a single word from the KAMAS language. KAMAS is much like FORTH in many respects; the syntax is similar enough that experience with FORTH makes a good prerequisite to programming in KAMAS.

The KAMAS language is made up of four large vocabularies—a major departure from FORTH, which lets you build new commands from a limited set of predefined FORTH words. The first KAMAS vocabulary is called Topicvoc. Using its commands, you can manipulate the KAMAS outline environment, but you don't have much real programming capability other than establishing procedures for data manipulation within the confines of KAMAS.

The second vocabulary is called Uservoc; it exists primarily to hold user-defined commands as you develop them. This feature, the ability to store and remember new commands, is known as extensibility and is another tie to FORTH.

The third vocabulary, Langvoc, which you can call from Topicvoc, is a complete language you can use for programming tasks beyond the scope of outline management. Sysvoc, the fourth vocabulary, adds command shortcuts to modify the basic structure of KAMAS.

Typically, programs written with Langvoc and Topicvoc are the source of

(continued on page 422)

Table 1: KAMAS *nomenclature. Note that leaves also may contain program code written in the* KAMAS *language and may be executed as utilities or separate programs.*

TOPIC: A text database organized into a hierarchy.

BRANCH: A section of a topic that includes a parent and any subordinate generations of descendants.

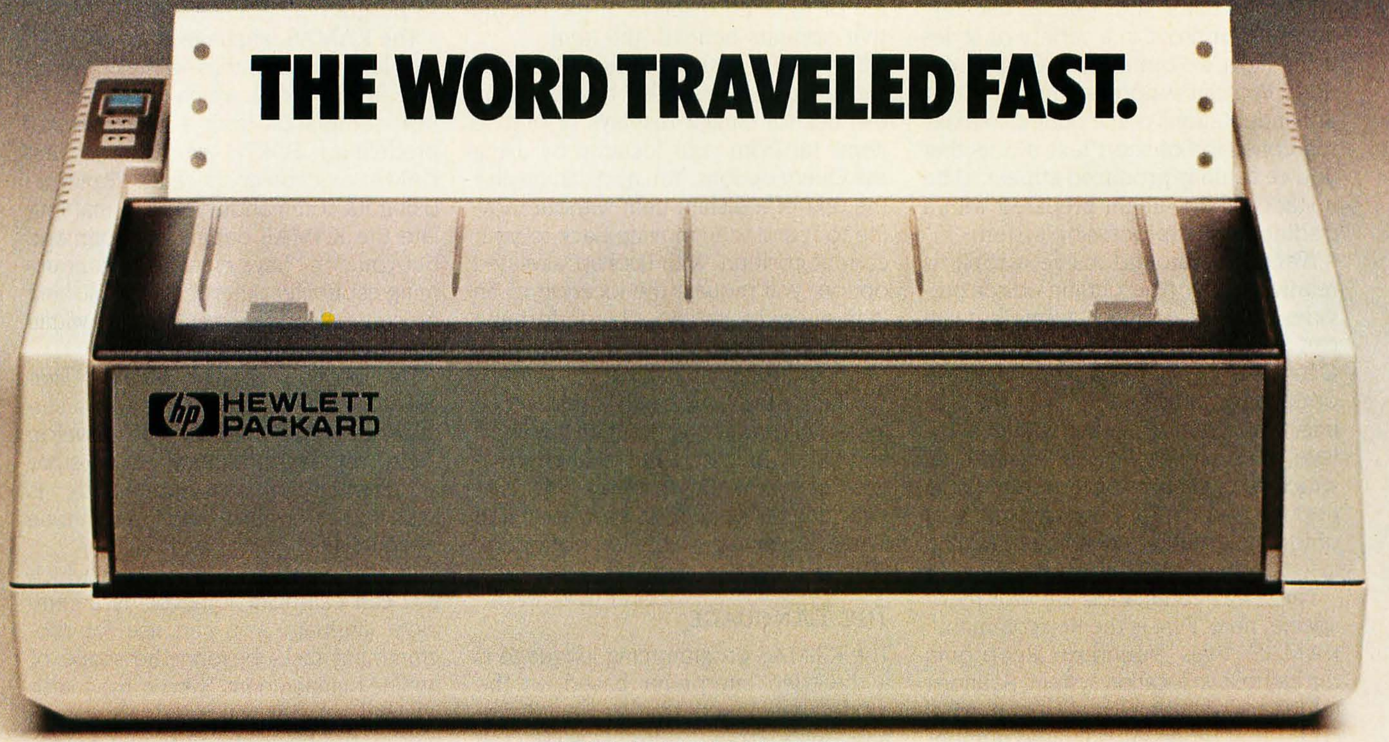
STEM: A single entry in the database. A stem can be the start of a branch or a descendant.

TITLE: The name of a stem.

KEY: The first, required, part of a title. Keys are used for rapid location of stems. May be up to 31 characters long.

SUBTITLE: Further description of a stem. Optional. Up to 63 characters.

LEAF: A block of text associated with a stem. Optional. Up to 2420 characters.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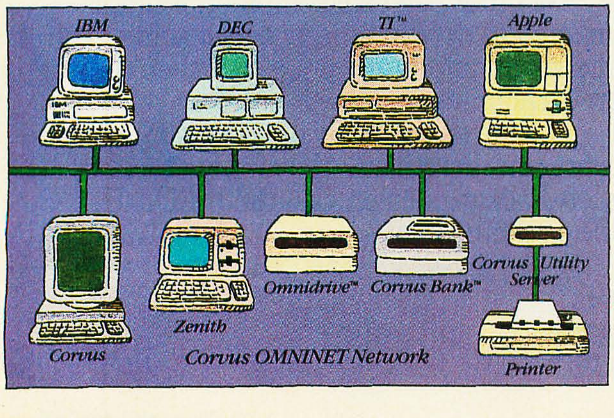

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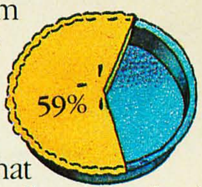

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CLUSTER ANALYSIS

A *pattern-recognition program in* BASIC

BY ROB SPENCER

WHAT DO TYPES OF microcomputers, species of bees, brands of beer, and groups of your relatives have in common? Among other things, they are all good subjects for *cluster analysis.*

Cluster analysis is a technique that can take a large amount of information about a number of objects and construct a simple, unique tree diagram that expresses those objects' similarities and differences at a glance. Your choice of objects depends on your applications. If your business is biochemistry and new drug design, as mine is, the objects might be fragments of molecules. If you're a biologist interested in the evolution and classification of insects, the objects could be species of bees. In market research, if the objects are different products, such as microcomputers or brands of beer, cluster analysis can help find competitive and noncompetitive relationships. Finally, if the objects are friends or relatives, cluster analysis can be an amusing party game.

The objects I've chosen to illustrate cluster analysis are twelve popular microcomputers. We'll begin with the output of the program, a tree diagram, also known as a dendrogram (figure 1). Here each computer is represented by a branch of the tree, and the branches are connected in pairs until each computer is somehow connected with every other computer.

The usefulness of cluster analysis and pattern recognition is apparent in the tree. The first two computers, the Compaq and the IBM Personal Computer (PC), are connected together and widely separated from all the others. They

(continued)

Rob Spencer (4230 Fieldgate Dr. #5, Mississauga, Ontario L4W 2M5, *Canada) is a biochemist with Syntex Inc.*

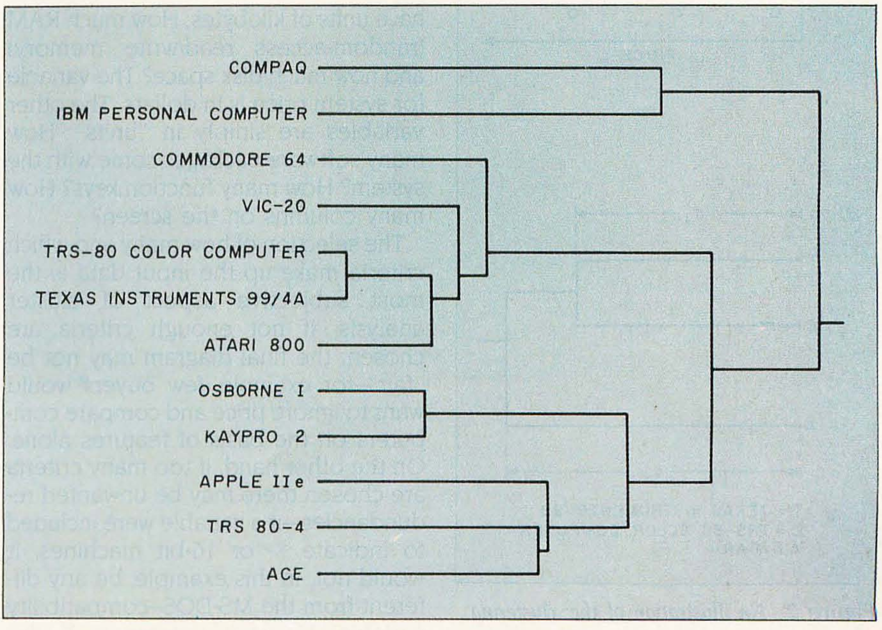

Figure 1: *This dendrogram is the result of cluster analysis on the microcomputer example. It shows the similarities and differences between the computers, based on nine input criteria.*

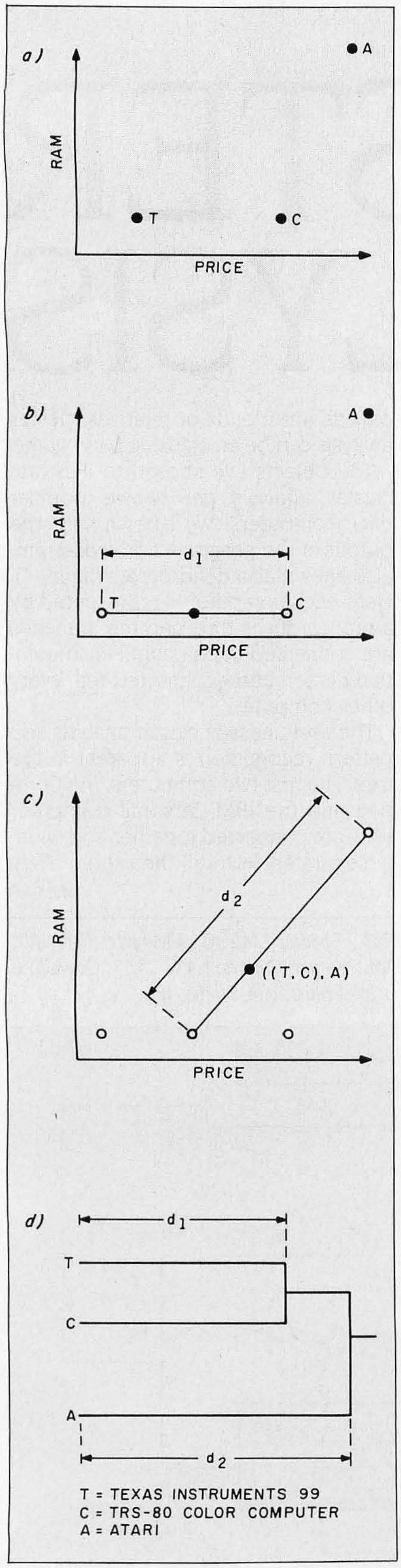

Figure 2: *An illustration of the clustering algorithm with a subset of the microcomputer data.*

clearly form a cluster of two, which we might call business computers. Similarly, the next five computers in figure 1 are all closely connected and separated from the rest by a long branch. We'd naturally conclude that these five are similar to each other and quite different from the others. Knowing something about these computers, we might say that this is the cluster of family or game machines—yet there's nothing explicit in the input data about business, families, or games. This is why cluster analysis is fun and useful—it can take a large amount of dry, objective information and produce a simple, thought-provoking diagram.

Most of the rest of this article will deal with the workings of cluster analysis, in the order used in the program: data input, data scaling, building the linked list, and (recursively) building the dendrogram.

INPUT DATA

To create the dendrogram in figure 1, I selected from an article in *Consumer Reports* (reference 1), nine different criteria that might be of interest to prospective buyers: price, amount of memory, portability, etc. (complete criteria are given at the end of listing 1, lines 1420–1580). The criteria were also selected to show the types of data that can be used. For example, several are yes/no variables (1 = yes, 0 = no) that deal with the questions: Is the computer MS-DOS compatible? Does it have a keypad? Is it portable? Other variables have units of kilobytes: How much RAM (random-access read/write memory) and how much disk space? The variable for system price is in dollars. The other variables are simply in "units": How many software packages come with the system? How many function keys? How many columns on the screen?

The selection of how many and which criteria make up the input data is the most subjective aspect of cluster analysis. If not enough criteria are chosen, the final diagram may not be "fair"—for example, few buyers would want to ignore price and compare computers on the basis of features alone. On the other hand, if too many criteria are chosen there may be unwanted redundancies—if a variable were included to indicate 8- or 16-bit machines, it would not, in this example, be any different from the MS-DOS–compatibility variable. Hartigan (reference 2) discusses these and other questions in detail.

SCALING THE DATA

How can kilobytes be compared with the number of function keys? How can dollars be compared to portability? To avoid these problems, all of the input data must be scaled or normalized before being presented to the clustering algorithm. In listing 1, this normalization is begun as the data is read (lines 140–230), where sums and sums of squares of the data for each variable are calculated. In lines 270-300 the means $(\hat{x}_k)$ and standard deviations (s_k) of each variable are calculated according to the formulas below:

$$\hat{x}_k = \sum_{i=1}^{np} x_{i,k} / np$$

$$s_k = \sqrt{\frac{\sum_{i=1}^{np} x_{i,k} - (\sum_{i=1}^{np} x_{i,k})^2 / np}{np - 1}}$$

These are used in lines 340–360 to convert the original data to *normal form*, in which each variable now has a mean of 0 and a standard deviation of 1:

$$x_{i,k} = \frac{x_{i,k} - \hat{x}_k}{s_k}$$

At this point the different variables could be given different weights, though I have not done so in the program. For example, if I decided that MS-DOS compatibility were very important, I could multiply that column of normalized data by a factor of 2 or 3 to give it extra weight in clustering.

THE CLUSTER ALGORITHM

The heart of the program is the building of a linked list in lines 400–730. Before discussing this in detail, I'll illustrate the algorithm with a small subset of the data. Figure 2a shows this reduced data set, three computers shown as points in the space "price" vs. "RAM." Since the data is normalized there are no units (dollars or kilobytes) for the axes. From now on, only distances between points are important. The algorithm goes as follows: 1. Calculate the distances between all pairs of points. 2. Select the two closest points; call them *i* and *j*. 3. Create a new point with coordinates that are an average of the coordinates of points *i* and *j*. 4. Discard points *i* and *j*. If there are two or more points remaining, go to step 1. Go through figure 2 with this algorithm. Without calculating

(continued on page 423)

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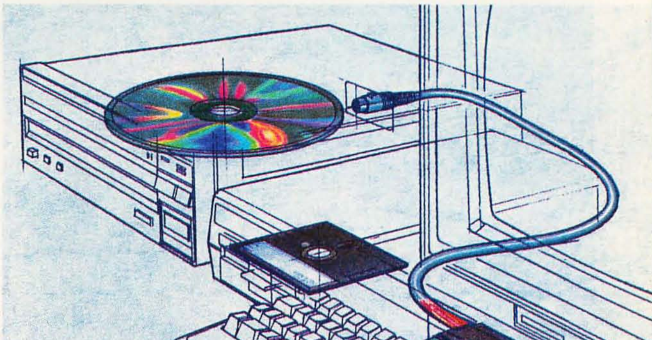

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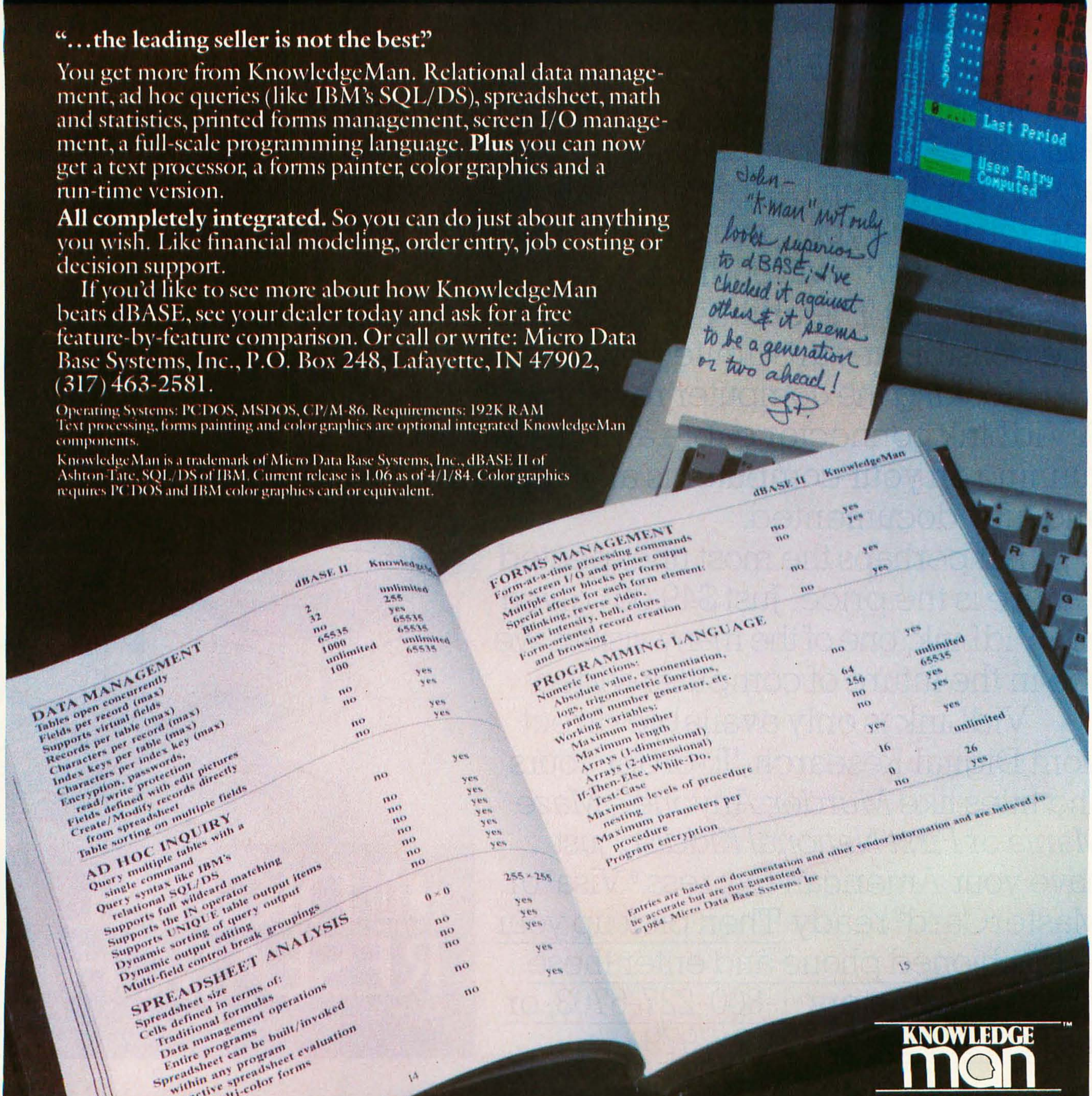

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Supports virtual fields	no	yes
Records per table (max)	65535	65535
Characters per record (max)	1000	65535
Characters per table (max)	unlimited	unlimited
Index keys per table (max)	100	65535
Characters per index key (max)		
Encryption, passwords, read/write protection	no	yes
Fields defined with edit pictures	no	yes
Create/Modify records directly from spreadsheet	no	yes
Table sorting on multiple fields	no	yes
AD HOC INQUIRY		
Query multiple tables with a single command	no	yes
Query syntax like IBM's relational SQL/DS	no	yes
Supports full wildcard matching	no	yes
Supports the IN operator	no	yes
Supports UNIQUE table output items	no	yes
Dynamic sorting of query output	no	yes
Dynamic output editing	no	yes
Multi-field control break groupings	no	yes
SPREADSHEET ANALYSIS		
Spreadsheet size	0 × 0	255 × 255
Cells defined in terms of:		
Traditional formulas	no	yes
Data management operations	no	yes
Entire programs	no	yes
Spreadsheet can be built/invoked within any program	no	yes
Interactive spreadsheet evaluation with multi-color forms	no	yes

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	dBASE II	KnowledgeMan
FORMS MANAGEMENT		
Form-at-a-time processing commands for screen I/O and printer output	no	yes
Multiple color blocks per form	no	yes
Special effects for each form element: Blinking, reverse video, low intensity, bell, colors	no	yes
Form-oriented record creation and browsing	no	yes
PROGRAMMING LANGUAGE		
Numeric functions: Absolute value, exponentiation, logs, trigonometric functions, random number generator, etc.	no	yes
Working variables:		
Maximum number	64	unlimited
Maximum length	256	65535
Arrays (1-dimensional)	no	yes
Arrays (2-dimensional)	no	yes
If-Then-Else, While-Do, Test-Case	yes	yes
Maximum levels of procedure nesting	16	unlimited
Maximum parameters per procedure	0	26
Program encryption	no	yes

Entries are based on documentation and other vendor information and are believed to be accurate but are not guaranteed.
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THE 65816 MICROPROCESSOR

PART 2: HARDWARE

System design considerations

WESTERN DESIGN CENTER'S 65816, a new 8-/16-bit CMOS (complementary metal-oxide semiconductor) version of the NMOS (negative-channel metal-oxide semiconductor) 6502 microprocessor aims to grant older systems a new lease on life. Its major contribution toward this rejuvenation is that it brings the speed of the clean, compact 6502 instruction set into the 16-bit arena. In part 1 of this article ("The 65816 Microprocessor, Part 1: Software," August BYTE, page 125), I discussed some of the instruction-set enhancements offered by this new family of microprocessors. Now let's examine the hardware considerations for system designers who either want to work with new designs or would like to adapt the 65816 to existing designs.

A number of processors in this new branch of the family will be produced, corresponding to the variety of processors currently available under the 6502 banner. As noted in part 1, I will refer to members of the NMOS 6502 group collectively as the 6502 and to CMOS 8-/16-bit members as the 65816. Most of the hardware signals are available on all the processors, but the vari-

(continued)

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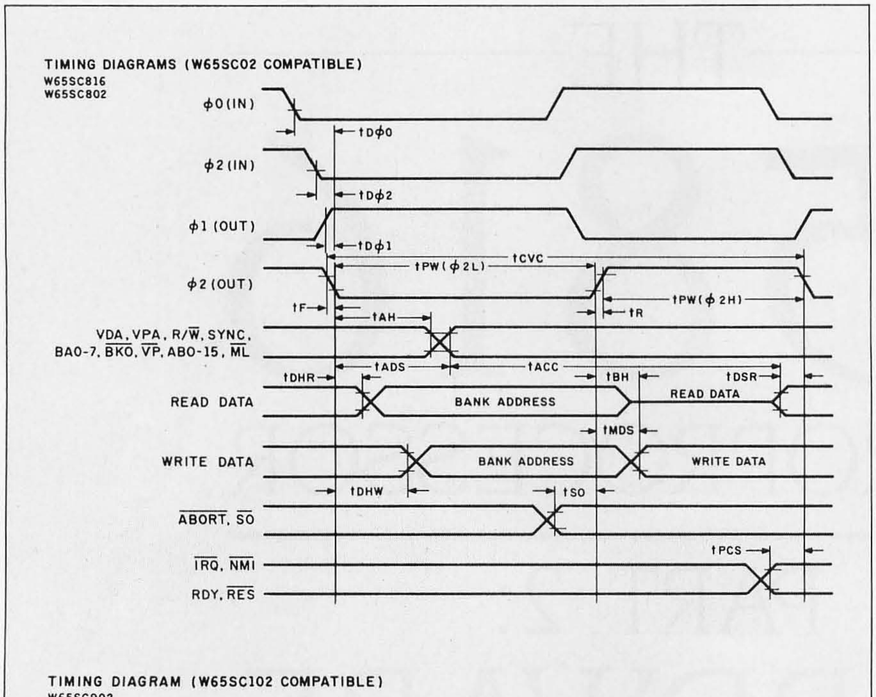
BY STEVEN P. HENDRIX

ous members bring different sets of the less commonly used signals out to external pins. Throughout this article, I will use a binary logic value of "0" to refer to a signal line at a voltage level of 0 volts, and a value of "1" to refer to a signal at a level of +5 volts. Some signals are considered "active" when they are at a logical "1" level and will be referred to as "active-high," while others are "active" at the logical "0" state and will be called "active-low."



NOTES:
1. LOAD = 100pF
2. VOLTAGE LEVELS SHOWN ARE VL < 0.4V, VH > 2.4, UNLESS OTHERWISE SPECIFIED.
3. MEASUREMENT POINTS SHOWN ARE 0.8V AND 2.0V, UNLESS OTHERWISE SPECIFIED.

Figure 1: *These timing diagrams show that on processors with a phase four clock signal, all signals except data are valid by the time they reach its rising edge.*

Table 1: VDA *and* VPA *can be combined to synthesize the equivalent of* SYNC.

VDA	VPA	Bus Cycle
0	0	Internal operation. Address and data buses idle.
0	1	Program byte fetch. May select a separate program memory.
1	0	Data byte read or write. May select a separate data area.
1	1	Op-code fetch. Equivalent to SYNC.

6502 Review

To provide a common point of departure for discussing the new features of the 65816, let's first review the signals provided by the 6502. The major signals make up a 16-bit address bus, an 8-bit data bus, and a variety of control signals. Different combinations of these signals are available on different members of the 6502 family; to keep package size down, some versions have as few as 28 pins.

The address bus consists of 16 pins designated as A0 through A15. These lines signal the address the processor accesses to read data from or write data to external devices. The state of A0 gives the lowest-order bit of the address, with A15 giving the highest-order bit. Some versions provide as few as 12 address bits externally. These lines can access only 4K (4096) bytes of memory or input/output (I/O) ports. Thus, they are used primarily in dedicated controllers such as smart printers or appliance controllers. Versions with the full address bus available externally can still directly access only 65,536 (2^{16}) memory or I/O locations. This limited address space is becoming a major restriction of the 6502 as memory prices fall and larger and larger systems become popular.

Pins D0 through D7 make up the data bus, either carrying data from the processor to other devices or from external memory or ports to the processor. Since this bus is bidirectional (carrying data either in or out), other signals are used to indicate the data flow's direction and to show when it is valid. On the 6502, the data bus carries valid data during only half of any processor cycle, and its state is undefined during the rest of the time. This unused bus bandwidth is important to the expanded 65816.

A variety of clock signals are available on the various 6502 processors. Some of them generate the clock signals internally, while others require all the clock signals to be generated externally. The first type is intended for designs with a minimum of external parts, while the second gives the hardware designer maximum flexibility in interfacing with other devices in the system. Three (active-high) clock signals are involved and are termed phase zero ($\phi 0$), phase one ($\phi 1$), and phase two ($\phi 2$), respectively. Phase zero is externally generated and is used as an input to some members of the family, which then de-

(continued on page 427)

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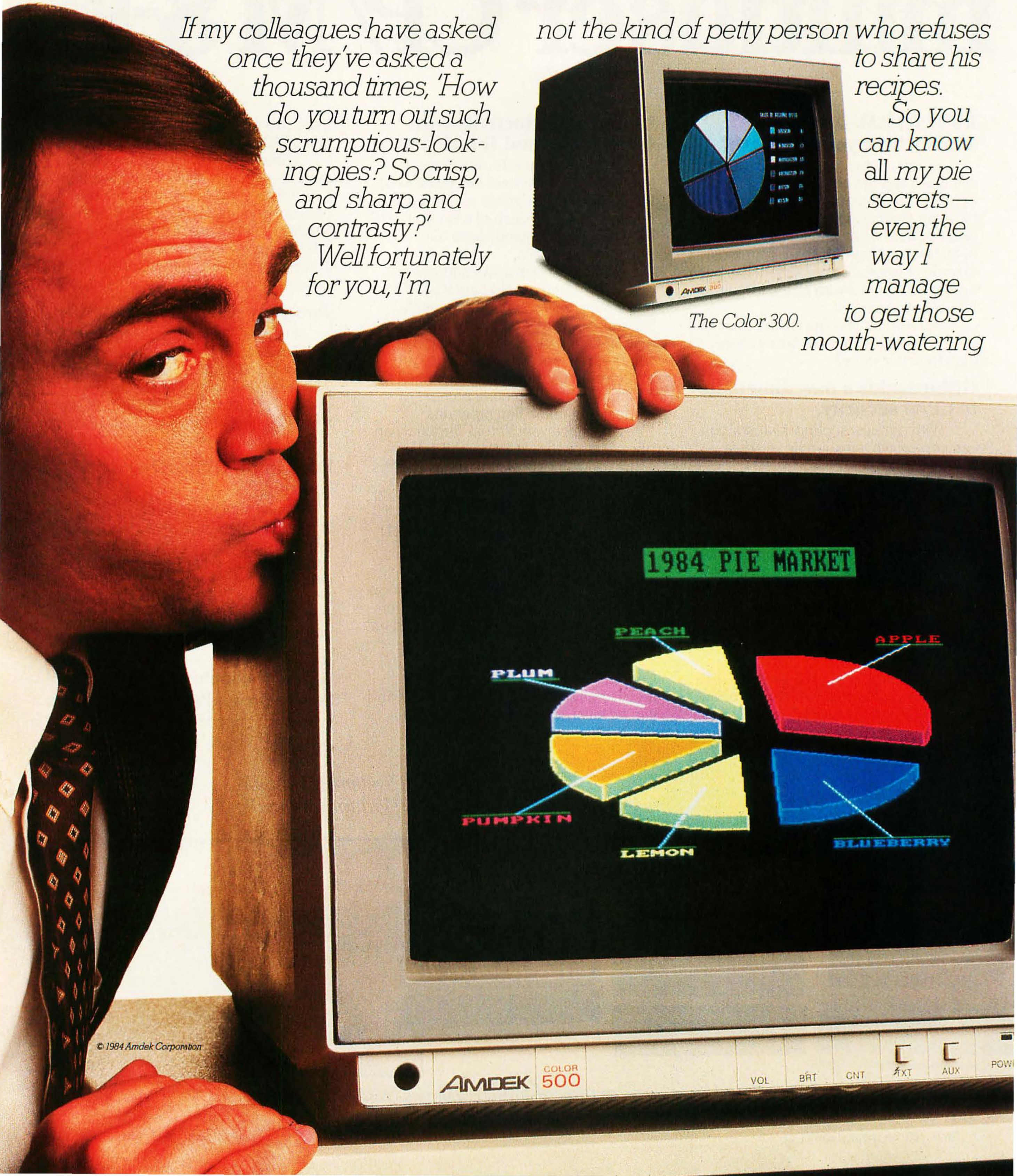
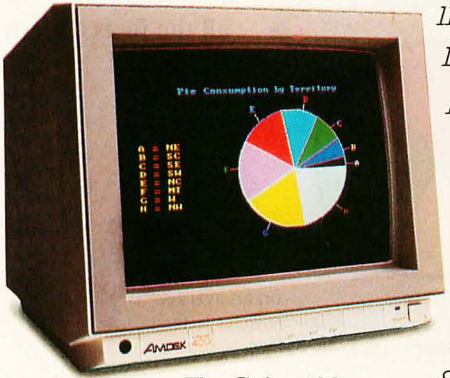


The Color 300.

AMDEK MONITOR, I'VE ALLY HEAVENLY PIES."

colors—lemony yellows; rich, chocolate browns; cherry reds.

It's really simple. The single most important ingredient in preparing a pie chart is the monitor. And in this chef's opinion, the name that stands above the rest is Amdek.



The Color 400.

PIE A-LA-GRAPHICS MODE.

Like all business graphics, the pie helps you communicate with greater clarity.

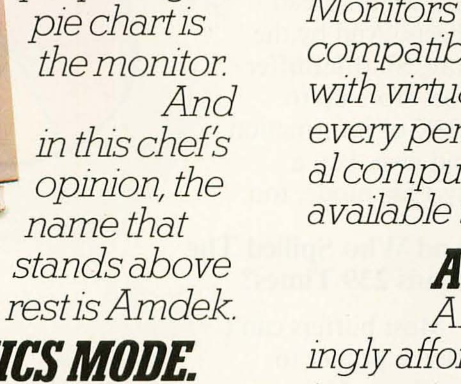
So you need a monitor that gives you loads of quality and reliability.

And features, too. All Amdek Monitors offer a black matrix picture tube for super color definition.

Some provide a built-in speaker, audio amplifier and headphone jack.

One model allows you to hook up to your VCR. Others let you flip a text switch and change the color to green, for easier reading.

Versatility is the key. From a relatively low-cost composite model, to an ultra high-resolution RGB unit (as high as 720(H) x 480(V)), Amdek has literally anticipated your monitor needs, present and future.

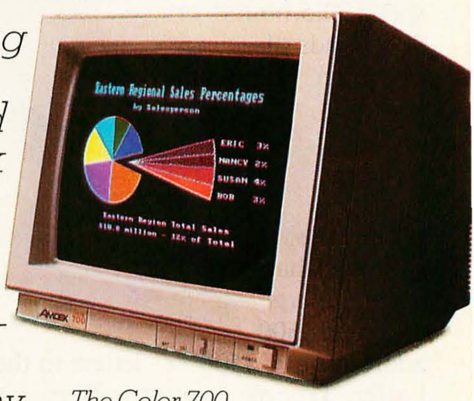


The Color 600.

ne Color 500.

APPLE PIES, IBM PIES, ETC.

One thing every pie-maker should know. Amdek Monitors are compatible with virtually every personal computer available today.



The Color 700.

A WORD ABOUT DOUGH.

Amdek Monitors are surprisingly affordable. Which allows you to turn out really first-rate pies at a price not limited to the upper crust.

And underscoring this value is a special Amdek plum. A two-year warranty on electronics, three years on the tube—the best warranty in the field.

BAKE-OFF.

Compare for yourself. For high-quality resolution, sharpness, color, styling and price, you won't find a better value than the Amdek Monitor.

And, why shouldn't people be saying about your pies what they're already saying about mine: That they rise above all others.

AMDEK COLOR MONITORS

Amdek Corporation, 2201 Lively Boulevard,
Elk Grove Village, IL 60007 Phone 312/595-6890

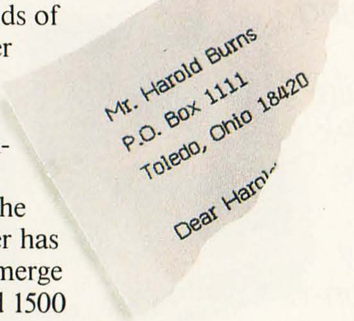
Circle 18 on inquiry card.

THE BUFFER DID IT.

Who Stole The 1500 Letters From The Computer?

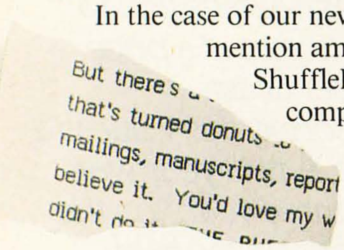
Let's just say you've got to send a letter to 1500 different people. Would you like to spend 22.5 hours* or 60 seconds of computer time?

With a garden-variety buffer, the computer has to mix, merge and send 1500 addresses and 1500 letters to the buffer. Trouble is, most buffers only store about 32 letters. So after 32 letters, the computer's down until the printer's done. Altogether, you're talking 22.5 hours.


Mr. Harold Burns
P.O. Box 1111
Toledo, Ohio 18420

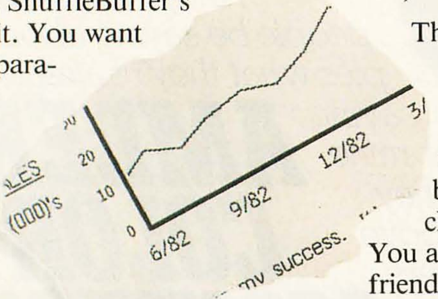
Dear Harol

In the case of our new (not to mention amazing) ShuffleBuffer, computer time is 60 seconds flat. Just give ShuffleBuffer one form letter and your address list, and it takes care of the mixing, the merging, and the printing. But that's not all ShuffleBuffer's stolen from the computer. Oh, no.


But there's a
that's turned donuts
mailings, manuscripts, report
believe it. You'd love my w
didn't do it

Who Changed and Rearranged The Facts?

Again, ShuffleBuffer's the culprit. You want to move paragraph #1 down where #3 is? Want to add a chart or picture? No problem. No mystery, either. Any buffer can give you FIFO, basic first-in, first-out printing. And some buffers offer By-Pass; the ability to interrupt long jobs for short ones. But only ShuffleBuffer has what we call Random Access Printing — the brains to move stored information around on its way to the printer. Something only a computer could do before. Comes in especially handy if you do lots of printing. Or lengthy manuscripts. Or voluminous green and white spread sheets. And by the way, ShuffleBuffer does store up to 128K of information and gives you a By-Pass mode, too.



And Who Spilled The Beans 239 Times?

Most buffers can't tell the printer to duplicate. If they can, they only offer a start/stop switch, which means you're the one who has to count to 239. Turn your back on your buffer, and your printer might shoot out a room full of copies. ShuffleBuffer, however, *does* control quantity. Tell it the amount, and it counts the copies. By itself.

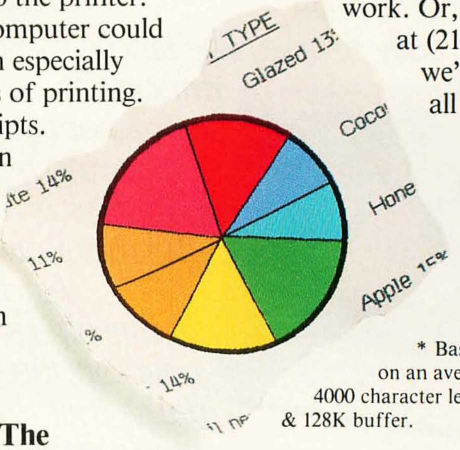
So, What's The Catch?

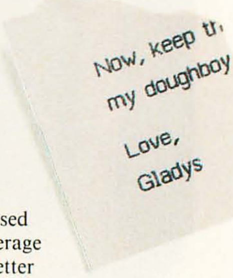
There isn't any. Sleuth around. You won't find another buffer that's as slick a character as this one. You also won't find one that's friendly with any parallel or serial computer/printer combination. This is the world's only universal buffer.

With a brain.

Who Wants You To Catch A ShuffleBuffer In Action?

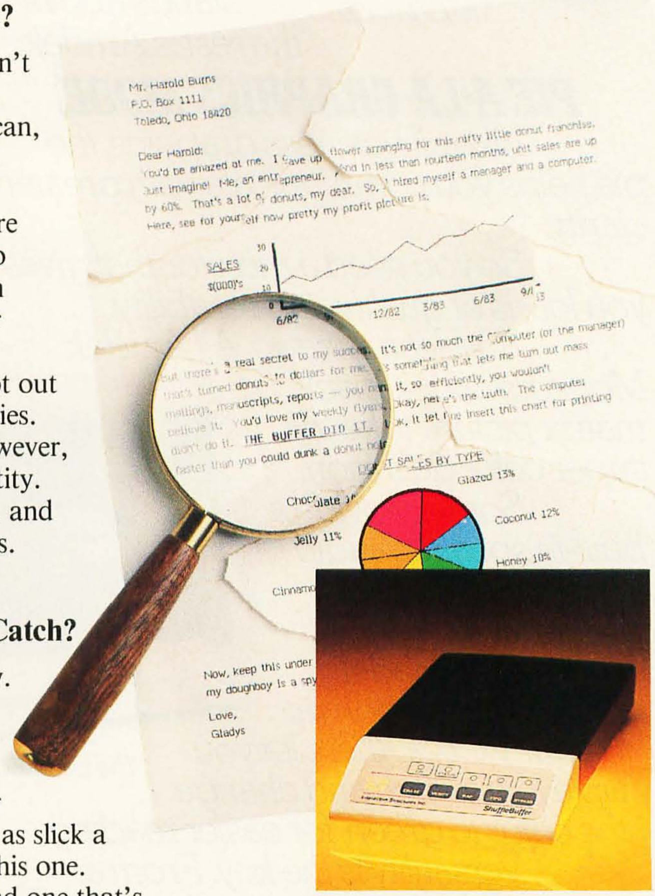
You guessed it. We do. Just go to your local computer dealer and ask him to show you a ShuffleBuffer at work. Or, you can call us at (215) 667-1713, and we'll clue you in on all the facts directly.




Now, keep th
my doughboy

Love,
Gladys

* Based on an average 4000 character letter & 128K buffer.


Mr. Harold Burns
P.O. Box 1111
Toledo, Ohio 18420

Dear Harold:
You'd be amazed at me. I gave up flower arranging for this nifty little donut franchise.
Just imagine! Me, an entrepreneur. And in less than fourteen months, unit sales are up by 60%. That's a lot of donuts, my dear. So, I hired myself a manager and a computer.
Here, see for yourself how pretty my profit picture is.

But there's a real secret to my success. It's not so much the computer (or the manager) that's turned donuts to dollars for me. It's something that lets me turn out mass mailings, manuscripts, reports — you name it, so efficiently, you wouldn't believe it. You'd love my weekly flyers. Okay, here's the truth. The computer didn't do it. THE BUFFER DID IT. Look, it let me insert this chart for printing faster than you could dunk a donut hole.

Now, keep this under
my doughboy is a spy

Love,
Gladys

ShuffleBuffer
The Buffer with a Brain

Interactive Structures Inc.
146 Montgomery Avenue
Bala Cynwyd, PA 19004

Circle 190 on inquiry card.

While it's easy to take a floppy disk for granted, this ubiquitous but unglamorous object is the foundation of much of our ability to use microcomputers at reasonable cost. It's cheap, portable, fast, and reliable. The fact that we rarely notice the floppy disk, and then only when something goes wrong, may lead us to regard it with indifference. On the other hand, like air, a floppy disk is no less important for all that we think so little about it.

The following articles direct our attention to the floppy disk and some of its unseen attributes. Robert Rodina's electron and optical microphotographs give us a rare look at the disk surface and point to possible reasons for differences in performance between brands. For those times when our disks scramble our bits, Thomas Sterling has written a piece on how to reorder them. Finally, Lester Thompson presents an in-depth look at various formatting techniques and how they affect you.

—Glenn Hartwig
Technical Editor

THE • FLOPPY • DISK

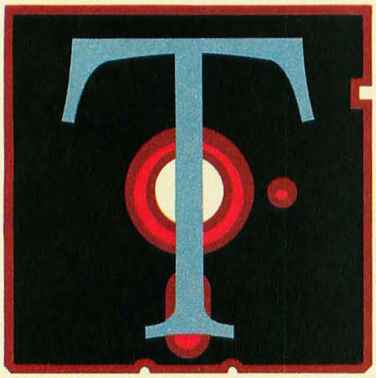
FOCUSING ON AN UNSUNG COMPONENT

ILLUSTRATIONS BY DANIEL PELAVIN

COMPARING FLOPPY DISKS

Subjective evaluation of magnetic media

BY ROBERT RODINA



The question "Which disk brand should I buy?" often comes from business associates and home computer users. In response to this query and to satisfy my own curiosity, I tested disks from the following manufacturers (brand/trademark in parentheses): Dysan Corp. (Dysan), Xidex Magnetics (Precision), Maxell Corp. of America (Maxell), Control Data Corp. (Control Data, or CDC), Wabash Datatech Inc. (Wabash), Memorex Corp. (Memorex), Nashua Corp. (Nashua), Minnesota Mining & Manufacturing Co. (3M), Verbatim Corp. (Datalife), BASF Systems Corp. (BASF), Athana Inc. (Athana), TDK Electronics Corp. (TDK), and International Business Machines Corp. (IBM). All brands were 5¼-inch, double-density, 48-tpi (tracks per inch) disks with reinforced hub rings. Results are listed in the same order the products were tested. In all cases but one, a total of 10 sample disks were tested for each manufacturer. A local 3M supplier provided 2 samples for review. The 3M-supplied sample of 10 disks arrived too late for testing.

The disks were visually examined and rated for such coating conditions as discoloration spots, visible coating streaks, and polishing patterns. These discolorations may or may not be electrically or magnetically significant. I used an International Scientific Instruments electron microscope to examine the discoloration spots at 1330 power and 3430 power. The light spots seem to be areas where a taller-than-normal buildup of iron oxide has received more than its share of buffing, while the dark spots appear to be minute depressions in the oxide coating skipped over by the polisher. A Zeiss optical microscope was used at 128 power to observe the polishing results. A highly polished medium would tend to improve drive-head-to-disk-surface contact and reduce head wear. Table 1 shows the results of this visual survey as they relate to the incidence of discoloration spots.

A normal medium as seen through the electron microscope is shown in photo 1, and a spotted area appears in photo 2. Photo 3 is typical of the samples that had the least polished media as viewed through the optical microscope. The Xidex surface appears in photo 4. The light areas in each photograph are highly polished regions. I judged the Xidex and Nashua brands as having the highest sheen, with the samples submitted by 3M, Memorex, Wabash, and BASF next, followed by the balance of the group.

OPERATIONAL TESTING

Two computers were selected for testing the disks. One computer contained two MPI (Micro Peripherals Inc.) disk drives and the other used one MPI and two Siemens drives. (The Siemens disk drive division is now called World Storage Technology.) All five drive heads were cleaned. Each drive head was then aligned using a Dysan model 282 alignment disk.

The first electrical test was to format each disk in double density, using a high-sensitivity 6DB6 test pattern. I then recorded a test program near track 39 using one of the Siemens drives. Next, the program was loaded and executed on each of the other four drives. All the disks passed this interchangeability test, which was designed to see if, as some manufacturers claim, a hub-hole tolerance of 0.0005 inch is better than a 0.001-inch tolerance at decreasing the probability of a parity read error. Apparently, no difference will be noticed unless this tolerance adds to an already misaligned drive head.

Next, I ran a speed test (table 2) to see if packaging friction affects rotational accuracy. The results are averaged over a 10-second period. The Dysan alignment disk was arbitrarily chosen to set the drive speed to 300 revolutions per minute (rpm). This speed test was combined with my evaluation of audible rotation noise, as judged by ear. No correlation was found between jacket-liner noise and rotation speed.

The last test measured recorded amplitude as a function of drive-head amplitude (table 3). An "FF" test pattern was recorded on tracks 16 and 39 of each disk. The FF pattern was chosen since it provided a relatively smooth test pattern. A Tektronix oscilloscope measured the amplitude at the output of the differential operational amplifier. The maximum resolution was about 5 millivolts (mV) using 50 mV per centimeter vertical sensitivity. Most

---

Robert Rodina (8014 Northwest Hillside, Weatherby Lake, MO 64152) is a part-time software consultant for Kinsey Packaging Equipment, Platte Woods, Missouri.

manufacturers do not include amplitude tests but perform similar ones called saturation and resolution tests, as specified by ANSI (American National Standards Institute) X3B8/78-145. Amplitude should not be a problem with good drives, but some brands have difficulty reading signals below 200 mV.

A wear test would have been useful but I had neither the time nor the sacrificial disk drives. Some disk manufacturers rate their products' life expectancy at 10 million passes before the oxide coating wears away. Based on 10 million passes, and to make a fair test of each brand, 13

(continued)

Photo 1: *An electron microscope view of a normal disk area at 1330×.*

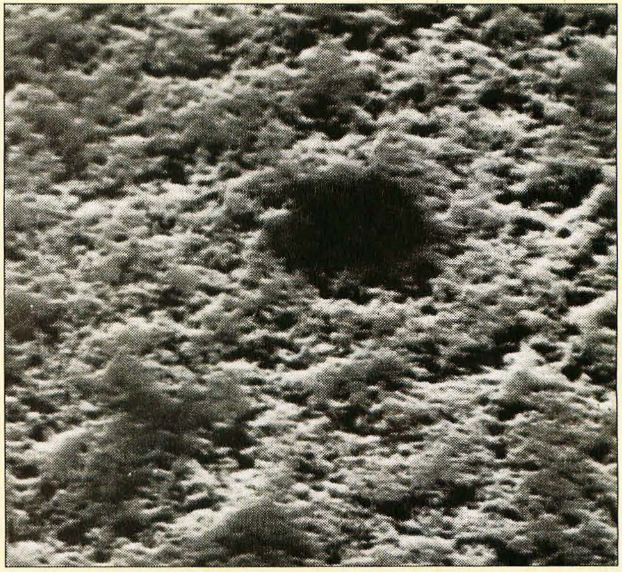


Photo 2: *The spotted area of a disk viewed at 1330×.*

Photo 3: A 128× *photograph of a disk typical of the least polished group.*

Photo 4: A 128× *photograph of a Xidex brand disk showing a marked improvement over photo 3.*

new disk drives would have had to run continuously for approximately 23 days each. Since I'm overendowed with neither time nor money, I decided to bypass this test.

OBSERVATIONS

I found that some of the Control Data Corp. (CDC) disks could not be formatted until they were bulk erased. It was also difficult to keep identification labels on the CDC jackets, including their own blue labels. These problems were brought to Control Data's attention and have been corrected with a variety of measures, including a new jacket design.

For some reason, possibly a difference in liner material, my personal Memorex single-sided, single-density disks operated much more quietly than the double-sided, double-density Memorex disks I surveyed.

The brands sampled did not include all suppliers. The 13 brands selected seemed to be the most popular, with the exception of Xidex, which just started manufacturing disks. Brands from companies that distribute disks but do not manufacture media of their own were not considered in this survey.

All the disks that were evaluated visually seemed to have flimsy jackets except for the 10-mil-thick Xidex brand (a mil equals 0.001 inch). Xidex and Nashua had the highest sheen on their media, denoting a highly polished surface and reflecting lower disk drive-head wear and lower dropout expectancy.

One manufacturer expressed the concern that samples received directly from other manufacturers might be “selected.” Based on my purchase of the two top brands after I finished this survey and subsequent retesting with consistent results, I concluded that special selection was unlikely.

CONCLUSION

What did all this prove? Only that if you have well-aligned drives in good electrical and mechanical condition and a good data-separation circuit, most any disk is probably usable. If you are having low drive-head amplitude problems, or if you have an operational amplifier in the drive circuitry that has lost some gain, you might want to consider a brand that gives up to a 20 percent higher recorded level and touts a tighter hub-hole tolerance. If you are concerned with head wear, choose a brand that has the most polished finish.

I have no doubt that if someone else conducted these same tests and observations, different results would occur. I hope others will come up with alternate approaches and publish their findings. ■

ACKNOWLEDGMENTS

Many thanks to Paul Gutshall for his electron microscope expertise, to Neil Winquist for his tutelage, and to all the manufacturers who submitted test samples.

Table 1: *Average number of discoloration areas per side. Discolorations may or may not affect the electrical and/or magnetic characteristics of a disk, but those due to inadequate polishing would tend to increase head wear.*

	0-4 Low	5-9 Medium	10 and up High
Dysan	•		
Xidex	•		
Maxell		•	
Control Data			•
Wabash	•		
Memorex	•		
Nashua		•	
3M	•		
Verbatim			•
BASF	•		
Athana	•		
TDK	•		
IBM	•		

Table 2: *Speed-test results were averaged over* 10 *seconds. Initial drive speed was set at* 300 *rpm.*

	Average Speed (rpm)		Noise	
		Low	Medium	High
Dysan	300.00	•		
Xidex	300.00	•		
Maxell	299.80	•		
Control Data	299.95	•		
Wabash	299.90		•	
Memorex	300.00			•
Nashua	300.00		•	
3M	299.90	•		
Verbatim	299.85	•		
BASF	299.90			•
Athana	299.95	•		
TDK	300.00	•		
IBM	300.00			•

Table 3: *Recorded amplitute in millivolts was measured as a function of drive-head amplitude. Manufacturers generally perform an* American National Standards Institute *test known as saturation and resolution, which is intended to provide complementary information.*

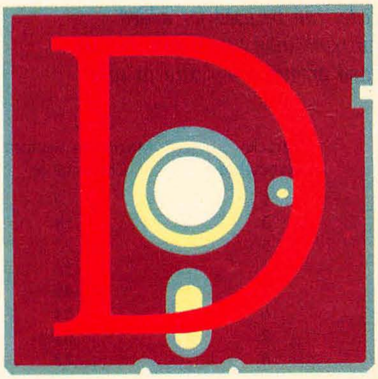
	Track 16	Track 39
Dysan	340	240
Xidex	370	250
Maxell	330	210
Control Data	360	240
Wabash	355	240
Memorex	330	215
Nashua	370	250
3M	350	240
Verbatim	330	210
BASF	335	210
Athana	360	240
TDK	340	220
IBM	355	235

THE·FLOPPY·DISK

THE THEORY OF DISK-ERROR CORRECTION

Algorithms for data recovery

BY THOMAS STERLING



Disk controllers are designed to provide error detection by adding a cyclic redundancy check (CRC) to each sector as it is written. In the event of an error, the CRC code signals the host computer that it will have to reread the disk sector. Unfortunately, the disk sector is sometimes unreadable and even repeated reads will not retrieve the data. In this article, I'll describe techniques for 100 percent recovery of data from multiple disk sectors that are otherwise unreadable.

The first example involves loading one disk track (nine sectors) with the information needed to correct any single track. I'll then describe how to extend this, using Reed-Solomon codes, to allow for the correction of any two tracks.

CORRECTING ONE BAD TRACK

The simplest means of error correction is the double-parity scheme in which parity bits are calculated both horizontally and vertically, as in table 1. If a single error exists, the parity bit will be wrong in both the row and column of that error, and we can fix the error simply by complementing that bit. This technique fails if either a row or a column has more than one erroneous bit. It is possible to improve error correction somewhat by using a CRC in the horizontal direction. This is shown in table 2.

The CRC will detect an error in a row, regardless of the number of bits that are in error in the row. Notice that it is now possible to correct an entire row. This method fails if errors are found in more than one row. While CRCs are not perfect, they are good enough that the possibility of one failing will be ignored in this presentation.

In the case of disks, data is recorded on concentric tracks. Thus, instead of having vertical and horizontal parity calculation, we have it from hub hole to outermost track (radial) and for the data stored in each concentric track (azimuthal). Because the disks already have error detection in the azimuthal direction (CRC), we merely need to add correction information (parity) in the radial direction. This is accomplished by making one track the parity-bit repository for all the other tracks, as in table 3. In other words, analyze all the other tracks using an exclusive-OR function (exclusive-OR is a logic operator having the property that if P is a statement and Q is a statement, then P exclusive-OR Q is true if either but not both statements are true, false if both are true or both are false). Track 80 is reserved for the parity-correction information.

How good is the error correction at this point? We can correct either any single sector in each radial slice or all nine sectors in a track, provided only one sector in a radial slice has an error. A significant improvement can be made by staggering the sectors by two as the radial parity is calculated, as in table 4. The pattern for tracks 1 through 9 repeats through track 79. Track 80 again is reserved for the parity-correction information.

By using this staggered or spiral parity, we can correct nine contiguous sectors on one radial slice while retaining the ability to correct any single track. Thus, the data lost to a radial scratch, for example, within a nine-track span and affecting only one sector in each track can be recovered.

Therefore, by using one track for correction and using spiral parity, we can correct

1. any single track (nine sectors)
2. any nine sectors in a radial slice
3. any four adjacent pairs of sectors in a radial slice
4. any set of sectors (up to nine) of which no two lie on the same spiral

When a bad sector is discovered, it can be recovered by using the exclusive-OR function on all other sectors in its spiral, including the sector on the correction track. This technique fails whenever more than one bad sector exists on any spiral. However, bad sectors in spirals that have only one bad sector still can be corrected even if other spirals have more than one bad sector.

(continued)

Thomas Sterling is a vice-president of Errex Inc., a firm that produces error-detection and error-correction programs and products. He is also a senior research associate in the physics department at the University of Michigan. He can be reached at 117 North First St., Ann Arbor, MI 48104.

Table 1: *Double parity is the simplest error-correction method.*

```
X X X X X X X ! P
X X X X X X X ! P
X X X X X X X ! P
X X X X X X X ! P
_________________
P P P P P P P
```

where X = data bit (1 or 0) and P = parity bit (1 or 0)

Table 2: *Cyclic redundancy checking can recover more than one erroneous bit per row but only in one row.*

```
X X X X X X X ! CRC
X X X X X X X ! CRC
X X X X X X X ! CRC
X X X X X X X ! CRC
_________________
P P P P P P P
```

Table 3: *Sector numbers used for parity calculation yield error detection in the radial direction on top of a cyclic redundancy check in the azimuthal direction.*

Track 1st	2nd	3rd	4th	5th	6th	...	79th	Parity Track
1	1	1	1	1	1		1	1
2	2	2	2	2	2		2	2
3	3	3	3	3	3		3	3
4	4	4	4	4	4		4	4
5	5	5	5	5	5		5	5
6	6	6	6	6	6		6	6
7	7	7	7	7	7		7	7
8	8	8	8	8	8		8	8
9	9	9	9	9	9		9	9

Table 4: *Staggering the sectors by two results in spiral parity calculation and increases the number of radial correctable sectors to nine.*

Track 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	...	Parity Track
1	3	5	7	9	2	4	6	8	...	6
2	4	6	8	1	3	5	7	9	...	7
3	5	7	9	2	4	6	8	1	...	8
4	6	8	1	3	5	7	9	2	...	9
5	7	9	2	4	6	8	1	3	...	1
6	8	1	3	5	7	9	2	4	...	2
7	9	2	4	6	8	1	3	5	...	3
8	1	3	5	7	9	2	4	6	...	4
9	2	4	6	8	1	3	5	7	...	5

Table 5: *Reed-Solomon codes let you reconstruct any two tracks.*

Given 8-bit bytes a, b, and c:

$a+b=c$	closure
$(a+b)+c=a+(b+c)$	associative
$a+b=b+a$	commutative
$a\times b=c$	closure
$(a\times b)\times c=a\times(b\times c)$	associative
$a\times b=b\times a$	commutative
$a\times(b+c)=(a\times b)+(a\times c)$	distributive

Given special elements 0, 1, and z:

$a+0=a$	additive identity
$a\times 1=a$	multiplicative identity
$a\times 0=0$	
$a\times a^{-1}=1$	inverse exists (except for 0)
$a+(-a)=0$	additive inverse

Of special importance:

$a+a=0$	Each element is its own inverse.
$z^n=a$	Each nonzero element of the set can be expressed as an integer power of the special element z.

Table 6: *Reed-Solomon codes can be used for added error-correction capability in more than two tracks, but the cost is increased overhead and greater complexity in code generation.*

Correction Tracks	Overhead Percentage	Tracks Correctable	Maximum Sectors Correctable
1	1.3	1	9
2	2.5	2	18
3	3.8	3	27
4	5.0	4	36
5	6.3	5	45
6	7.5	6	54
7	8.8	7	63
8	10.0	8	72

REED-SOLOMON CODES

Any two tracks can be reconstructed by adding a radial Reed-Solomon code that would be stored in a second correction track. (Reed-Solomon codes are thoroughly discussed in *Error-Correcting Codes* by W. Wesley Peterson and E. J. Weldon Jr. [The MIT Press, 1972].) It would be calculated using the same spiral techniques as for the parity above.

The Reed-Solomon codes for 8-bit bytes are based on the fact that we can define multiplication and addition for bytes that satisfy the rules in table 5.

This type of structure is called a finite Galois field (Évariste Galois was a 19th-century French mathematician). Addition for the Galois field is bitwise exclusive-OR. Multiplication is complicated and beyond the scope of this article. The important distinction from regular arithmetic comes from the closure rule: the multiplication of two 8-bit bytes is itself an 8-bit byte.

In order to use the Reed-Solomon code for data bytes

$d_1, d_2, \ldots d_n$, we find two unique check bytes, c_1 and c_2, such that

$$d_n + d_{n-1} + \ldots + d_1 + c_2 + c_1 = 0$$

and

$$(d_n \times z^{n+1}) + (d_{n-1} \times z^n) + \ldots + (d_1 \times z^2) + (c_2 \times z) + c_1 = 0$$

The first equation is the parity described earlier. The second equation is new and more complicated.

When a single bad sector is found, the relationship in the first equation shows that it can be corrected by adding the corresponding bytes in all the other sectors in its spiral (including c_1 and c_2, as shown above). If two bad sectors exist, the correction is more difficult. Assume we have bad sectors n_1 and n_2; then

$$d_{n_1} + d_{n_2} =$$

$$d_n + \ldots + d_{n_1+1} + d_{n_1-1} + \ldots + d_{n_2+1} + d_{n_2-1} + \ldots + d_1 + c_2 + c_1 = S_0$$

$$[d_{n_1} \times (z^{n_1+1})] + [d_{n_2} \times (z^{n_2+1})] = [d_n \times (z^{n+1})] + \ldots + [d_{n_1+1} \times (z^{n_1+2})] + \ldots + (c_2 \times z) + c_1 = S_1$$

We can now find d_{n_1} and d_{n_2} in terms of S_0 and S_1:

$$d_{n_1} = \frac{S_1 + [(z^{n_2+1}) \times S_0}{(z^{n_2+1}) + (z^{n_1+1})}$$

$$d_{n_2} = \frac{S_1 + [(z^{n_1+1}) \times S_0}{(z^{n_2+1}) + (z^{n_1+1})}$$

Therefore, by using two tracks for correction information, we can correct

1. any two tracks (18 sectors)
2. any 18 sectors in a radial slice
3. any nine adjacent pairs of sectors in a radial slice
4. any set of sectors (up to 18) of which no 3 lie on the same spiral

Reed-Solomon codes can be made to use any number of check bytes, but the generation and correction become increasingly difficult. For each extra track of correction capability, another track of check bytes is needed, as shown in table 6.

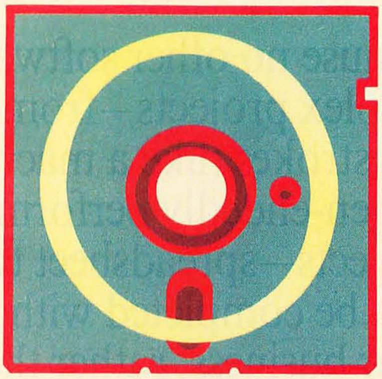
CONCLUSION

The application of Reed-Solomon codes to information stored on disks can provide an effective means of recovering unreadable sectors. The low overhead percentage needed to retain the correction information makes the use of error detection and correction viable on disks. ■

FLOPPY-DISK FORMATS

Shedding some light on tracks, sectors, fields, and encoding schemes

BY LESTER E. THOMPSON



Of the four primary technologies that let a computer handle, store, and manipulate data—applications software, the operating system, the controller, and magnetic media formatting—generally the least is known about media formatting. Most programmers and users work with the applications-program part of the operating system. They don't know much about controllers and formats because they are isolated from these technologies. In this article, I'll look at the most popular disk formats available and try to dispel some of the mystery surrounding incompatibility and standardization.

Before a floppy disk can be used in a computer, it must be formatted with a magnetic pattern. This pattern forms the structure that stores data in discrete concentric circles called *tracks*. Tracks are accessed by a magnetic head that is stepped mechanically from track to track under computer control. The format serves as a road map for the computer and helps it locate and retrieve stored information. The format tells the computer where to enter the data and how to find it later on.

There is no standard format in the computer industry. Different formats are chosen to enhance hardware costs, data-storage capacity, reliability, speed of data access,

(continued on page 436)

Lester E. Thompson is president of Formaster Corp. (1983 Concourse Dr., San Jose, CA 95131), which manufactures data-duplication and piracy-protection products.

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BIG PROJECTS ON SMALL MACHINES

Software engineering on microcomputers

BY WILLIAM F. APPELBE AND ALEX POURNELLE

IF YOU ARE a programmer, you were probably first introduced to programming by means of small, simple problems. After mastering a dozen or so small programs you may have become somewhat overconfident in your programming talent. After all, since it took you only a couple of hours to write and debug a 100-line program to print mail labels, you may think that it should take only 50 times as long to write a 5000-line compiler. Although you do have to understand such things as system calls, code files, etc., all of these are documented in some fashion, so there really is no reason you should not be able to develop a major software product on your own, right?

Wrong!

Overconfidence in your own programming ability can cause you to ignore the major hurdles to successful development of large software projects: project management and organization. Large software projects typically take one man-day per 10 lines of *delivered* (i.e., tested and debugged) source code. This means that it might take you as long as 500 days to develop a 5000-line compiler. The 10-lines-per-day figure includes all the time it takes to design, code, and test the program and write the documentation.

Typically, less than 20 percent of the project time is actually taken up writing code; the rest goes into organizing the project and designing and testing the code.

SOFTWARE ENGINEERING

Ideally, you need a disciplined, methodical approach to develop software. Unfortunately, no one approach is universally applicable to all software projects. Nevertheless, there are many effective tools available to assist you in designing, coding, testing, maintaining, and organizing software projects.

Until recently, microcomputers generally were not capable of supporting large software systems because of their limited memory and small, slow storage (cassette tapes and low-density floppy disks). However, the advent of powerful 16- and 32-bit microprocessors, inexpensive memory, and hard-disk and RAM-disk drives has meant that microcomputers are now capable of supporting complex software such as databases and sophisticated word processors. In addition, a wide range of software tools such as compilers can be bought for most popular microcomputers.

Thus, computer enthusiasts are beginning to develop large software projects. Fortunately, tools and techniques exist to minimize the risk of developing a software flop.

Most colleges offer introductory and advanced programming courses in various languages, but rarely do they offer courses to teach students to develop large software projects. Thus, most professional programmers learn software engineering on the job, from co-workers and their own mistakes.

THE SOFTWARE LIFE CYCLE

The software life cycle can be roughly divided into six phases: requirements analysis, specification, design, coding, testing, and maintenance.

During the requirements-analysis phase you have to determine what the software should do and what environment it will be used in. Requirements analysis also involves estimating the resources (such as time, money, and personnel) needed to develop the software and documentation.

In the specification phase you determine the software's components and the interfaces between components.

During the design phase you describe the

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Alex Pournelle is chief programmer at Workman and Associates (112 Marion Ave., Pasadena, CA 91106). He also attends the University of California at San Diego and is collaborating on a textbook. He would like to hear from people working on low-cost graphics visuals.

algorithms and data structures used in each software component.

In the coding phase you code the software components in the programming language you've chosen during the requirements-analysis phase.

In the testing phase you check each of the software components and then test the combined components that form the complete system.

The maintenance phase is an ongoing process. You have to correct bugs found after the software has been "released" and adapt the software to new applications and environments.

The organization and tools necessary to successfully complete a software project depend on who the users will be and the size of the project. If you are developing software for your own use, testing, maintenance, and documentation can be incidental. If you are developing software intended for naive or remote users, then it is critical to make sure you understand the user's needs during requirements analysis before you start to design and code the software.

ESTIMATING PROJECT SIZE AND DIFFICULTY

The most common way to estimate the size of a project is to estimate the number of lines of source code in the product. A small project (up to 1000 lines of source code) can be developed by a single person. Larger projects (1000–10,000 lines of code) are usually developed by a small team. And still larger projects are often divided among several teams.

Since you will not know the exact number of lines of source code the project will have until you are finished coding, it is vital to get a good estimate before you start. There are two ways to get an estimate:

1. Ask someone who has completed a similar project. This is the best approach because such an "expert" can give you a lot of helpful suggestions. However, there are two pitfalls in this approach: the expert may be more talented than you, and the project may not be as similar as you think.
2. Determine the size of a program that is similar to the project you are contemplating (see table 1 for some examples). Even if you can only estimate the size of the object code, this will give a good hint as to the size of the source code.

It's a good idea to design or implement a small prototype of your program to get some idea of the size of each of the components of the system. The more you know about your subject, the better your final program is likely to be.

GUIDELINES FOR A LARGE SOFTWARE PROJECT

Although there is no universal rule for successfully developing large software projects, there are guidelines that apply to the majority of software projects. The guidelines we will discuss are based on our experience supervising and participating in team software projects, including a project to develop compilers for a subset of Ada, written in Pascal, assigned to all computer science undergraduates at UCSD.

GETTING STARTED—ANALYZING PROJECT REQUIREMENTS

The most important, and often overlooked, first step in developing any software project is getting a good definition of what the software should do and how it should interface with users and other software and hardware. In the case of a compiler project, this includes getting a reference manual for the language, deciding on the object language the compiler will generate (e.g., assembly language or binary code), and deciding how "user friendly" the compiler will be.

In some projects it is difficult to get a precise definition of the user's requirements. In such cases the best approach is to build a *prototype*, test it on users, and then redevelop the software as necessary. Make sure the prototype is of manageable size.

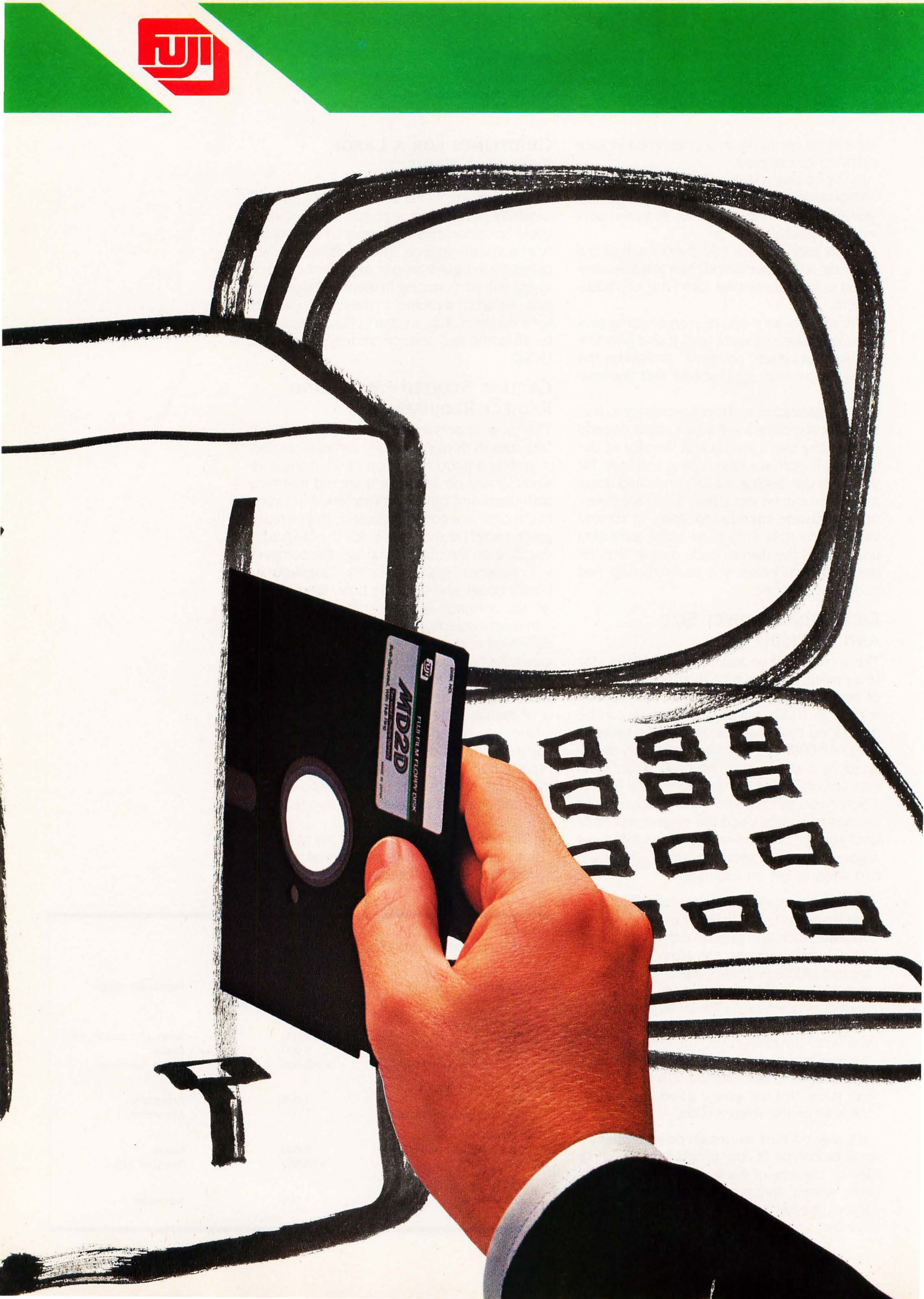
Once you have a good definition of what the software should do, estimate the size of the project. If the project is more than a few thousand lines of code it is probably too big for one person alone to develop for two reasons:

1. Time—Even working full-time it is unlikely that you could produce as many as a hundred lines of debugged and tested code

(continued on page 446)

Table 1: *Software project sizes.*

Software	Approximate Size (lines of source code)	Source Language
Operating Systems		
CP/M	2,000	Assembler and PL/I-80
UCSD Pascal	5,000	Pascal
UNIX (includes utilities)	>100,000	C and Assembler
Assembly languages		
Simple	1,000	Assembler
Complex (includes macros)	5,000	Assembler
Compilers		
Pascal (without optimization)	6,000	Pascal
Ada	>50,000	Pascal or Ada
Applications		
dBASE II	4,000	Assembler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MD2D
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Graphics

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THERE'S A WORLD of change occurring in the microcomputer industry and graphics is a big part of it. Since the creation of computers, more and more power has been packed into smaller and smaller boxes and the price of that power has continued to drop. We have seen accounting systems, process control, high-level mathematics, and many other functions move from mainframes to microcomputers, at first with limited capabilities and then often with greater power and ease of use than the original mainframe system had. Originally, microcomputers were limited by their memory capacity, but as miniaturization and technology have progressed that problem has been solved. Consequently, today we have essentially micro-mainframes.

For many years, the really exciting, creative, eye-grabbing graphics created on computers have been the exclusive realm of large mainframe systems. This is changing. Currently the microcomputer's main limitations lie in the areas of processing speed and image resolution. Calculation and processing speeds have increased incredibly since the advent of microcomputers and there is every reason to believe that this trend will continue, although undoubtedly at a slower rate. And image resolution is one of the major concerns of the microcomputer graphics community today. There are new developments taking place that modify the whole concept of resolution and greatly increase the potential for microcomputers in graphics. One of these developments is discussed in "From Pixels to Microdots."

What are we capable of now? And where are we going? These are the questions on which this issue is based. Peter R. Sørensen's article "Fractals" delves into the fascinating—and beautiful—world of complex mathematics and its relationship to the world around us. Joan Collins and Doug Tucker provide us with a glimpse into the spectacular world of laser graphics in entertainment with "Laser Graphics and Animation." And the private, creative world of the artist is opened for our eyes in "The Computer as an Artistic Tool" by Isaac Victor Kerlow.

"Real-Time 3-D Graphics for Microcomputers" by Marcus Newton provides an assembly-language routine for 16-bit microcomputer animation, while Lee Baldwin explores the importance of color in computer graphics systems with "Color Considerations."

For readers who would like to experiment with computer art but aren't satisfied with the transient nature of an image on a computer screen or its size on a 35mm slide, Daniel Cooper shows us how to create silk-screen originals from microcomputer graphics in "Computer Landscapes."

And there is a short but unusual section on computer-generated art. The unusual part of "Editor's Choice" is the lack of attending copy. This is a purely visual section which we hope you will enjoy.

Some of these articles are noticeably beyond the scope of today's microcomputers, but if the past is any indication, the future is not far away.

—Jane Morrill Tazelaar, Technical Editor

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FRACTALS

BY PETER R. SØRENSEN

Exploring the rough edges between dimensions

THIS IS AN ADVENTURE story about some contemporary explorers, the territories they are pioneering, and the strange beasts that inhabit those distant lands. The explorers are mathematicians, their virgin territories are fractional dimensions (fractals), with immaterial landscapes and monsters that can be seen only on computer screens.

The story began in the latter part of the last century when a few maverick mathematicians started to rebel against the idealistic concepts that had persisted in mathematics since the days of Euclid. The prevailing thought was that the universe could be described in terms of the perfect forms of standard geometry and the dynamics of Newton. But nature isn't simple and orderly enough to fit that description. "Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line," says Dr. Benoit B. Mandelbrot, the 59-year-old French mathematician who is the foremost fractal pioneer today (he coined the term "fractal"). Mandelbrot was inspired by those early mavericks, people such as Cantor, Peano, Hausdorff, and Koch who dared to go against the establishment (for which they were rewarded by having their theories termed a "gallery of monsters," "pathological," "psychotic," and even "terrifying").

Nonetheless, they forged ahead for some fifty years—until the 1920s. However, their discoveries were not widely embraced until 1975 when Mandelbrot used fractals as the starting point for his own research. "I show," he says, "that behind their very wildest creations, unknown to them and to several generations of followers lie worlds of interest to all those who celebrate nature by trying to imitate it. In addition, fractal geometry reveals that some of the most austerely formal chapters of mathematics had a hidden face: a world of beauty unsuspected until now." (Reference 1.)

Fractals have a great many faces. Sometimes they are "dragon curves," convoluted lines that twist and turn with mind-boggling complexity, or they can be made to look exactly like mountain ranges. Perhaps the most fascinating are the four-dimensional fractals, with their bizarre and beautiful organic contours that we can see only in three-dimensional slices. Fractals can even mimic the activity of the stock market, the motion of molecules, and the growth of plants. Consequently, their uses range from physics, biology, and sociology, to art and even motion-picture scene simulation.

Whatever form they take, fractals would be almost impossible to create without the aid of computers. This is true because, while the formulas that generate fractals are fairly simple, they must be calculated over and over—each time using the result of the previous calculation as the start of the next. All but the simplest are calculated millions of times. And, the calculation aside, the rendering of the result requires the precision of computer graphics for proper execution—as a glance at the accompanying figures will show.

WHAT ARE FRACTALS?

A widely held but mistaken belief equates fractals with random numbers. Actually, random fractals are only one special breed of fractal—the kind that imitates natural phenomena. In particular, the ability of fractals to generate mountains with startling realism has caught the public's attention. The peaks and valleys of these mountain ranges, as well as the texture on their slopes, are determined randomly, of course, but that's not the fractal part. The fractal component is what controls the generation of the random numbers so that you

(continued)

Peter R. Sørensen (Second Genesis, 6867½ Fountain Ave., Hollywood, CA 90028) is a freelance author and computer-graphics consultant who has designed and directed special effects for film and video. He spoke at the National Computer Graphics Association (NCGA) conference.

can get rugged peaks like the Rockies or gentle slopes like the Catskills. Many other kinds of fractals, the so-called "Dragons," for instance, are not random at all.

The one essential element of fractals is their peculiar fractional dimensionality. And, in practice, every fractal that has ever been of use has also had *self-similarity* in one way or another—the small parts look like the big parts—but even that isn't a mathematical requirement. (Note that random fractals are statistically self-similar, so even though they don't repeat their pattern exactly, they clearly have the same look to them, no matter what level of their detail you observe. See photo 1. This is a series of enlargements that depict this self-similarity.)

Here is where the adventure really begins—with the exploration of these fractional dimensions. You may know that a straight line is considered to have one dimension, a flat plane has two dimensions, and a volume of space has three. All very neat and tidy stuff from classical mathematics, but that's our jumping-off point. Now Euclid would say that the dimensions fit into neat pigeonholes, first, second, or third (we'll get into the fourth a little later), but the maverick mathematicians challenged that notion and said that between the first and second dimensions was a continuous blending, as one dimension blended into two dimensions, and so on.

Mandelbrot explains, "Mathematicians recognized during their 1875-1925 crisis that a proper understanding of irregularity or fragmentation (as of regularity or connectedness) cannot be satisfied with defining dimension as a number of coordinates. To my mind the main fact is that the loose notion of dimension turns out to have many mathematical facets that not only are conceptually distinct but may lead to different numerical values."

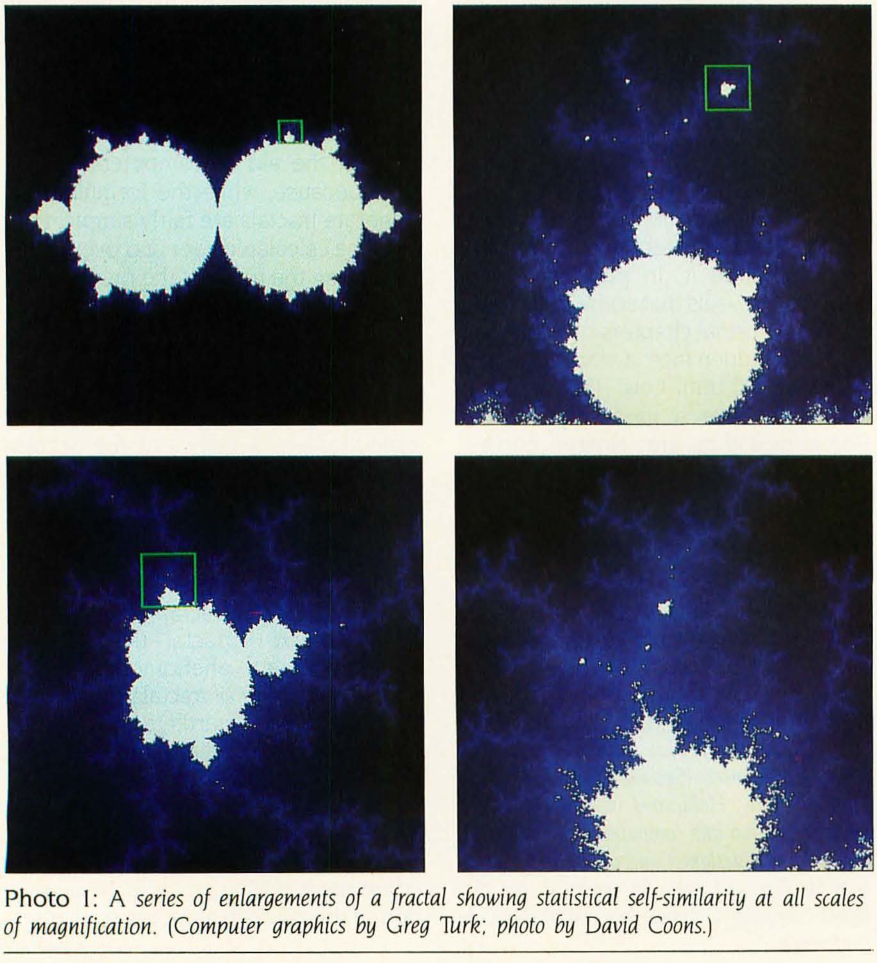

Photo 1: A *series of enlargements of a fractal showing statistical self-similarity at all scales of magnification. (Computer graphics by Greg Turk; photo by David Coons.)*

Consider the wiggly line in figure 1a. In traditional topology the line would be said to be one-dimensional even though it exists in two-dimensional space. But in the way the maverick Felix Hausdorff defines dimension, the line's dimensionality is 1.8687 because—and what follows will be an intuitive explanation rather than a technical one—the more complicated the wiggles get, the more the line's single dimension approaches the second dimension, until it could become infinitely wiggly, infinitely long, fill the plane, and be thoroughly two-dimensional. Notice also, that the larger features of the shape are the same as the smaller ones in figure 1b, which again illustrates the concept of self-similarity. See also figure 2, a *self-homeographic fractal*. (Note that these are nonrandom fractals.)

Just because the mathematicians have more than one way of defining dimension doesn't mean that one way is right and the other way is wrong. Both the Hausdorff and the topological definitions are valid and functioning tools, although it took half a century of warfare to get the new definition accepted. This business of dimension is so basic to the structure of the universe that we shouldn't be surprised if it has apparently contradictory qualities—just as light seems to be both a particle and a wave.

When randomness is included in the fractal equation, the geometric beauty of the nonrandom fractals changes to the organic beauty of natural form. The branching of trees, the meandering of streams, the awesome expanse of stars and galaxies throughout the heavens—even the scattered paths of nuclear particles—are all natural fractals.

A frequently used illustration of fractals in nature is the measurement of continental coastlines. Mandelbrot uses Britain as an example, observing that the ragged outline on a map of the island has a fractal dimension somewhat greater than 1. If you look at a map with greater detail but the same scale, the coastline's length seems to increase. "The result is most peculiar: coastline length turns out to be an elusive notion that slips between the fingers of one who wants to grasp it. All measurement methods ultimately lead to the conclusion that the coastline's length is very large and so ill determined that it is best

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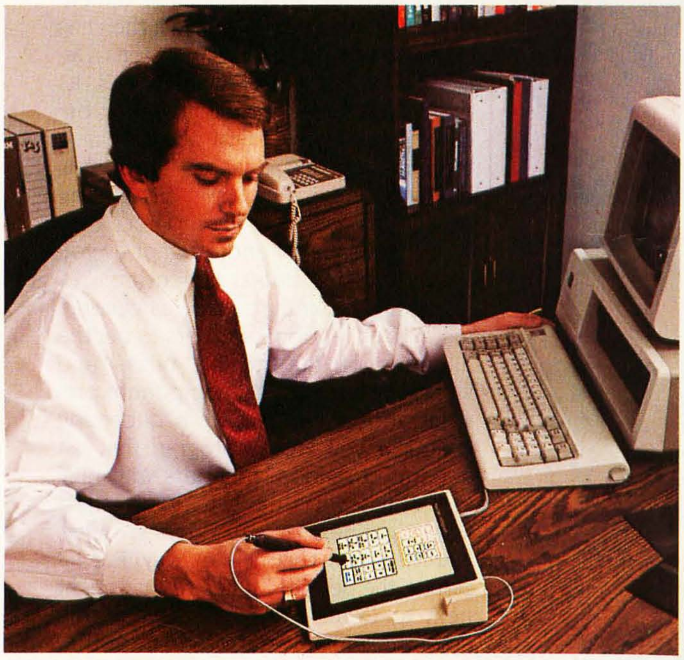

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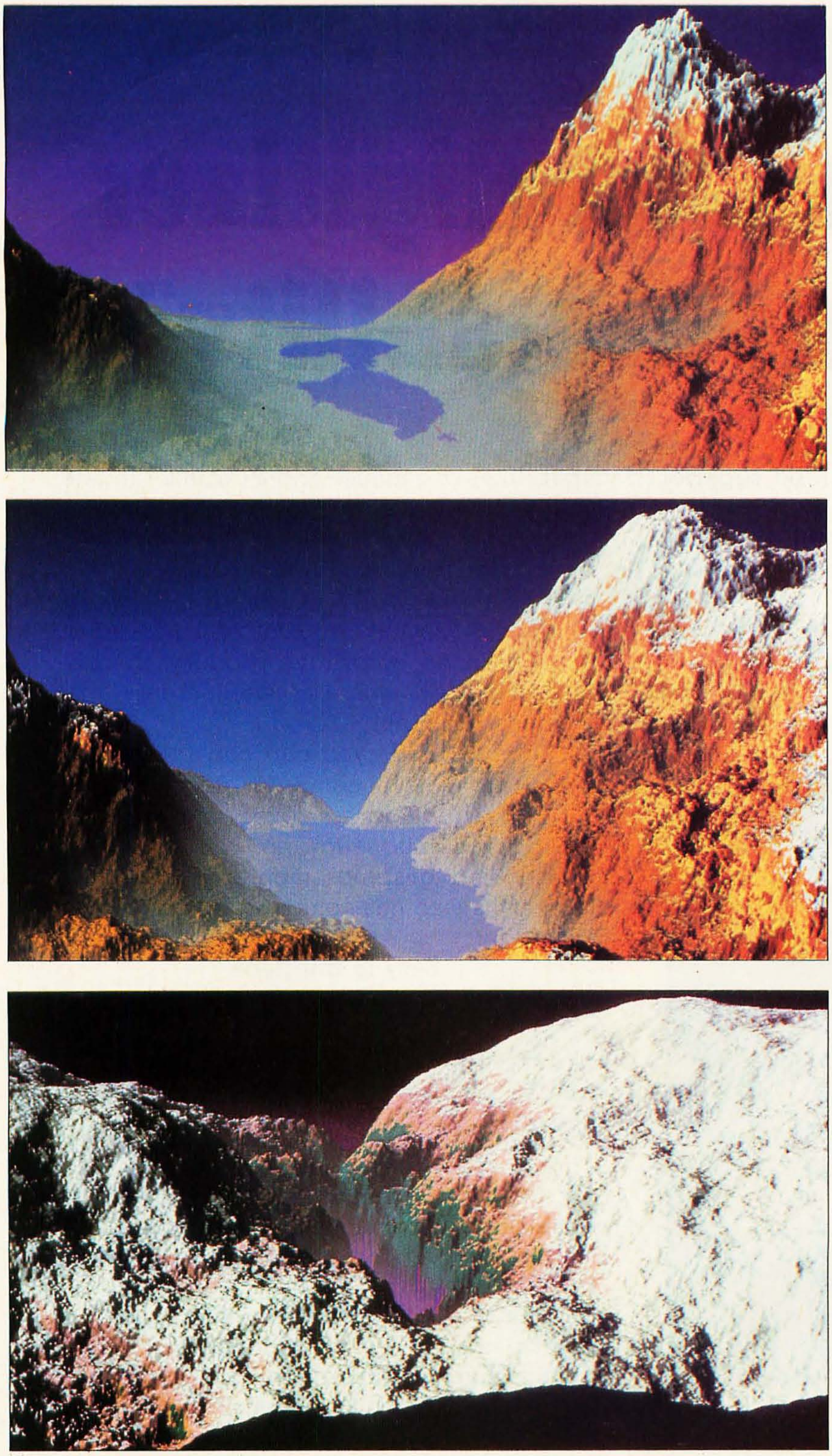

Photo 2: *These three images show how different kinds of fractal landscapes can be created from the same random database by accentuating or supressing the vertical scale in various ways. Notice that you can find exactly corresponding details in each scene. The pictures were created by* Dr. Richard F. Voss *in* 1983 *as improved versions of similar mountains that appear in* The Fractal Geometry of Nature.

considered infinite."

You can imagine what it would be like if you were to walk around Britain measuring the coast. If you used a yardstick you'd get a considerably shorter length than if you used a pair of calipers set a centimeter apart. Then you could go completely crazy and measure around every grain of sand—assuming you could stop the motion of the water. You get the idea. This "experiment" also shows how self-similarity is limited in the physical world, since the coastline has the same texture on several different scales, but as you continue to zoom in you reach a point where you can detect the difference between beaches, rocky shores, and marshlands. Still, the sand, rocks, and mud can all be described with their own fractal equations.

So far we have been investigating the fractal qualities of lines. We can easily extend the notion of fractional dimension to surfaces—which is where the mountains come in. A perfectly flat sheet of aluminum foil, for example, is essentially a two-dimensional surface. If you wrinkle it up you cause it, in the topological sense, to fill three dimensions, but in the fractal sense it then has two-plus-some-fraction dimensions. Depending on just how wrinkly it is, its dimension increases. Only when it became infinitely wrinkled would it have three dimensions as far as Hausdorff is concerned. So if you are generating mountains on your computer, they would get rougher and rougher as you increased their fractal dimension.

Creating mountains involves generating a lot of random numbers to get the altitudes of the myriad peaks and valleys, but the fractal component prevents those numbers from becoming chaotic. If you wrote a program that just generated random numbers willy-nilly you could wind up with your tallest peak right next to your deepest valley. Nature doesn't work that way. For instance, the peak of Mt. Everest isn't right next to Death Valley. And while you could tinker with your program so that it would take neighboring altitudes into account, you'd not be properly imitating nature unless you reinvented fractals.

When making fractal mountains there are several tricks you can use to get different kinds of terrain from the same

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fractal dimension. For instance, mountains usually have foothills that level off, even though they may be generated from the same fractal. As the vertical scale increases above a certain level you can easily increase or decrease the value of the altitude numbers to get the desired contrasting contours. Photo 2 shows three remarkably different landscapes created from the same random fractal database by Dr. Richard F. Voss at the IBM Thomas J. Watson Research Center. You can see that the relationships between the various mountains and between the lowlands and the mountains can be made to vary dramatically. The scene's coloration is related to altitude but "tweaked" so that the landscape doesn't look like it was just dipped in paint up to various levels.

Creating such landscapes with strict mathematical purity is computationally expensive. But, since fractals can enrich the quality of computer graphics in motion pictures and television, shortcuts have been devised to speed up the process of picture generation. Foremost in this specialized application of fractals is the computer graphics team at Lucasfilm. (See "Simulating Reality with Computer Graphics," by Peter R. Sørensen, March BYTE, page 106, for examples of fractal mountains and plants created by the Lucasfilm team.)

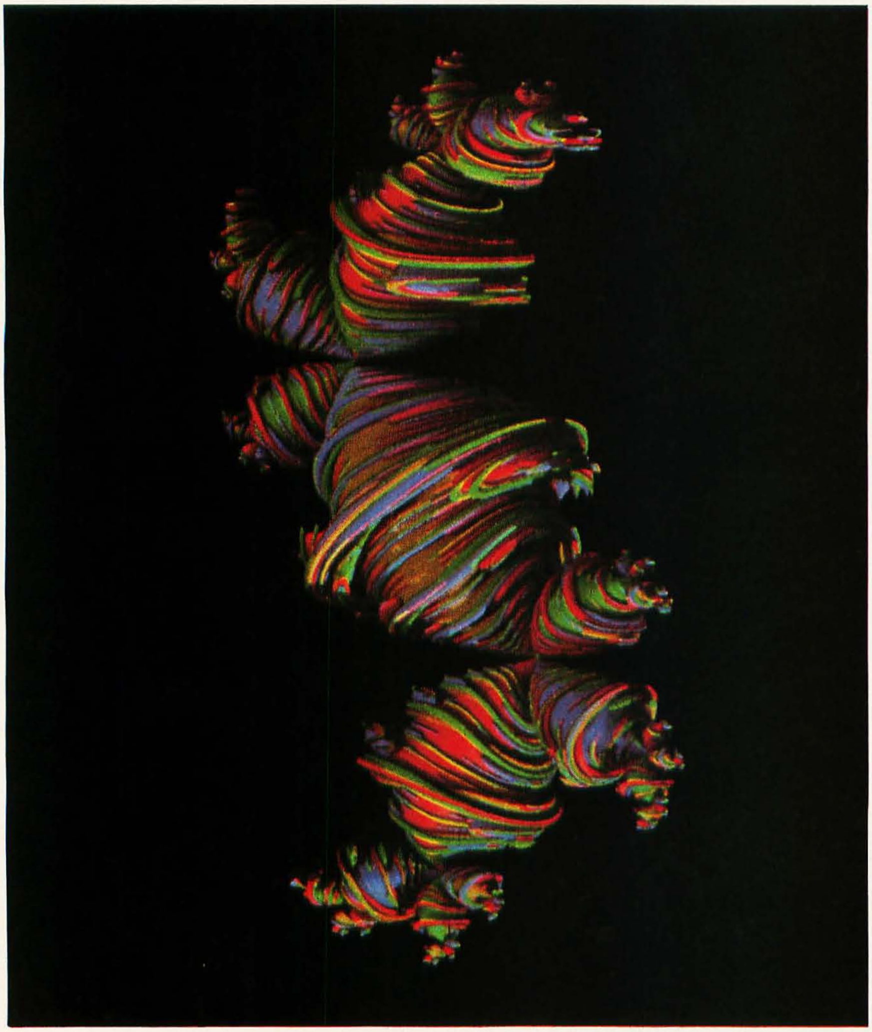

Photo 3: A *four-dimensional generalization of a self-squared dragon by* Alan Norton *displaying all of its different components. Its formula is:* $1.06i\ X(1-X)$. *If you plug the first factor in* Norton's *formulas into Greg Turk's program (listing 1), you will get a slice of the three-dimensional dragon.*

THE FOUR-DIMENSIONAL FRACTAL ZONE

At last it's time to step boldly into the fourth dimension. Einstein defines the fourth dimension as time, and as far as our existence in the world is concerned, that's true. But there are other ways of defining the fourth dimension, and the one we're going to explore can be thought of as being at 90 degrees to the first three dimensions. Now, obviously there is no way you can fit a fourth 90-degree angle into our physical space—which explains why time suits the other definition so well. As far as mathematicians are concerned, the numbers can be made to work that way and produce useful results, so let's take them at their word. Among the more interesting phenomena out there are the algebraic operations known as *quaternions*.

Intriguingly, you can only do normal arithmetic in three places: in one dimension (the kind of everyday math we use to balance our checkbooks), in two dimensions (known as the "complex plane"), and in four dimensions (the quaternions). You can't do addition, multiplication, subtraction, and division in other spaces such as 8-, 16-, or 32-dimensional space—perhaps it's just as well. But the 4-dimensional quaternions can do a lot for fractals.

Alan Norton is a computer scientist at the IBM Thomas J. Watson Research Center who is currently working on development of parallel-processing supercomputers. He is also a hunter who stalks his prey in the fourth dimension—often late at night when the other researchers have gone home and the research center's mighty array processors are available to him. Of all the fractals, his are the most interesting (see photo 3 for an example of these photogenic dragons.). They have a peculiar déjà-vu quality, as if you've seen them before, but not on Earth. This "familiarity" results from the fact that these objects are shaped by the fractal laws that have molded the environment we live in, but they are alien as well because their spawning ground is elsewhere. (Remember that his quarry lurks in the fourth dimension, so we can only view a three-dimensional "slice" of the beast, which in turn must be printed on a two-

(continued)

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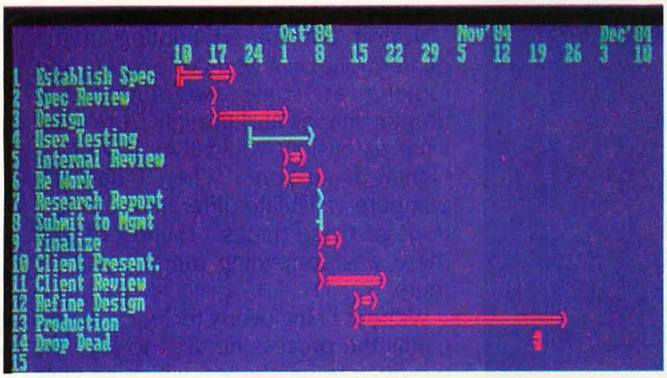

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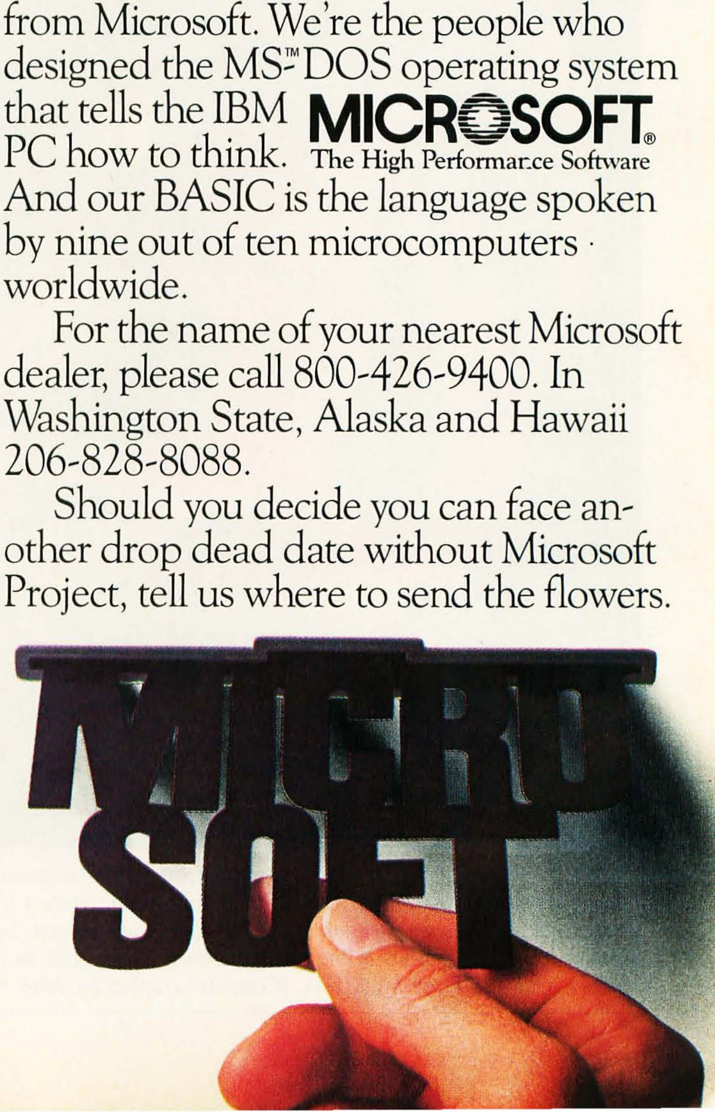

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dimensional piece of paper.)

Norton modestly discounts the importance of his contribution to our perception of existence. When asked if he thought of himself as a fourth-dimension hunter on a photographic safari he said, "No, I'm just throwing my camera out there into the dark, taking snapshots." Well, okay—but in his case the camera is a sophisticated computer program that he wrote, and in order to write it he must have put in a fair amount of time studying his subject and practicing his "throw."

He says that the idea of dimension is, "sort of a continuum of ever-increasing detail. There's a whole progression . . . an infinite number of possible dimensions . . . but in between [the dimensions], we haven't had measuring sticks that are very convenient . . ."—before fractals, that is. ". . . Anything for which the dimension turns out to be somewhere on the continuum between whole integers would necessarily be a fractal. Not only do fractals have a funny dimension, but magnifying them will give you something that looks statistically the same: self-similarity that is unvarying under the change of scale. That gives you something you can work with and it turns out to be surprisingly effective.

"Why is it that nature is self-similar is the mystery. That nature is fractal is no mystery. Nature is fractal because nothing is perfectly smooth; a perfectly smooth surface is a mental abstraction. On the other hand not everything is self-similar, but the fact that it turns out to be so useful is the surprising thing that comes out of what Mandelbrot has been doing."

Norton got started hunting in the quaternions on a whim one day. "I was looking at some two-dimensional dragon shapes and thought, 'I wonder what extension would they have to a higher dimension?' When I had the computer calculate different cross sections of these things I found out that there was something funny going on there."

Without being overly technical, he explains the process he uses to look for the quaternion shapes, which he calls "Domains of Attraction." "I apply the simplest sort of dynamical rules for four dimensions and these rules cause points to be attracted to stable orbits or cycles, sort of like the way matter in the solar system was attracted to the planetary orbits. If you were in this universe where things don't behave according to the laws of gravity, but according to the simplest mathematics possible, then these are the sort of shapes that emerge in this world [see photo 4]. [Interestingly enough], there is even a notion of a special direction that would correspond to time in our world. But it doesn't correspond to the kind of behavior you would see in physics, the formulas which I use only take into account a very small part of the things that can happen in physical reality.

"There are a few parameters that I can vary to make the shapes look different. They have different fractal dimensions, so I can make them look much more rugged or be relatively smooth. The simplest example would be if I use the

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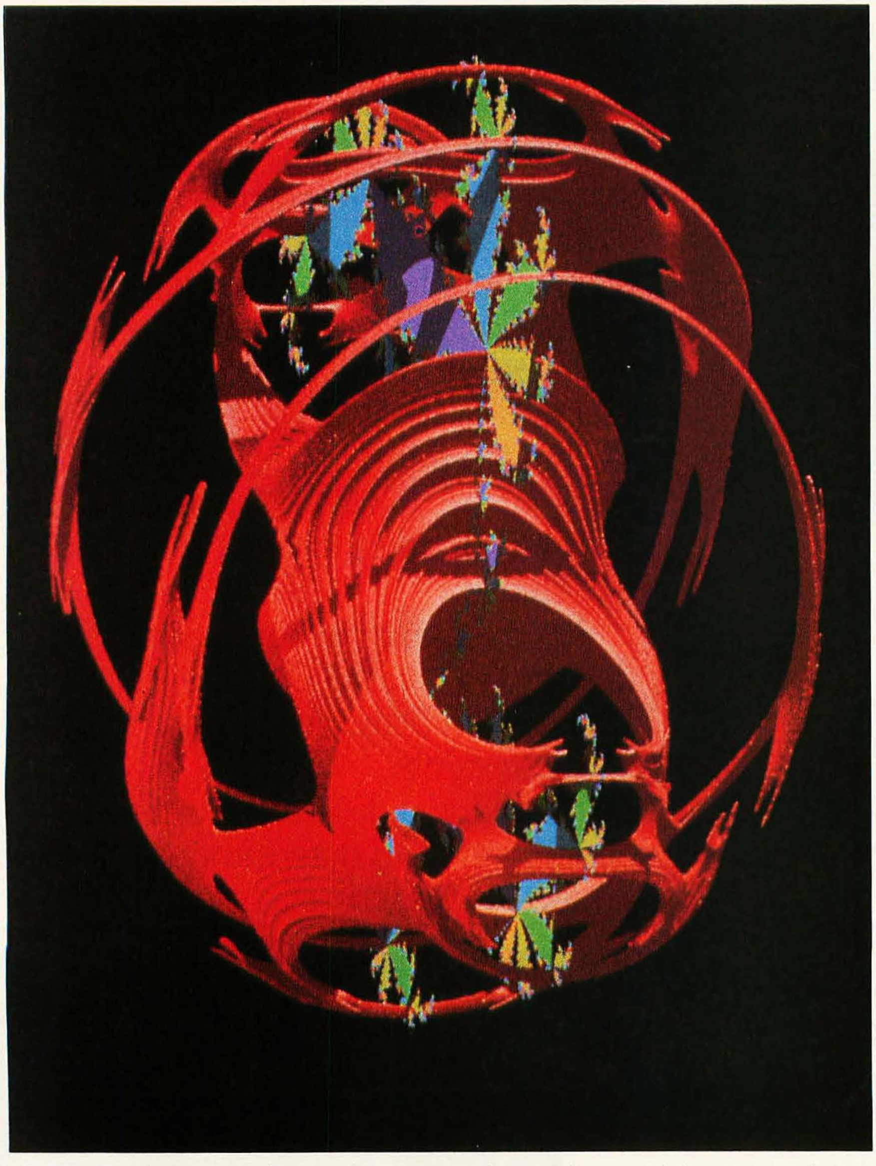

Photo 4: *Red quaternion domain of attraction with a two-dimensional dragon curve slicing through its middle. We can see how the three-dimensional creature (itself a slice of a four-dimensional shape) is an extension of the two-dimensional dragon. In this case, there are six different colored components in the two-dimensional dragon, but we only follow the red. Its formula is:* (1.475+0.906i) $X(1-X)$. (*Computer graphics by* Alan Norton.)

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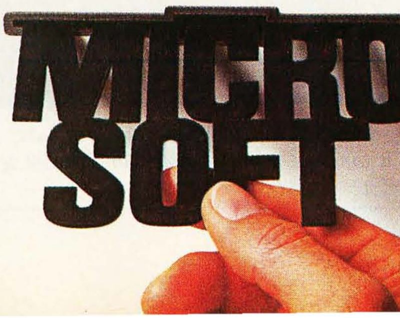

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Photo 5: *Fractal spirals with domains of color indicating how fast the generating function pushes non-fractal points away from their points or origin. Red is the fastest; blue, the slowest.* (*Fractal program by Greg Turk; color program by David Coons.*)

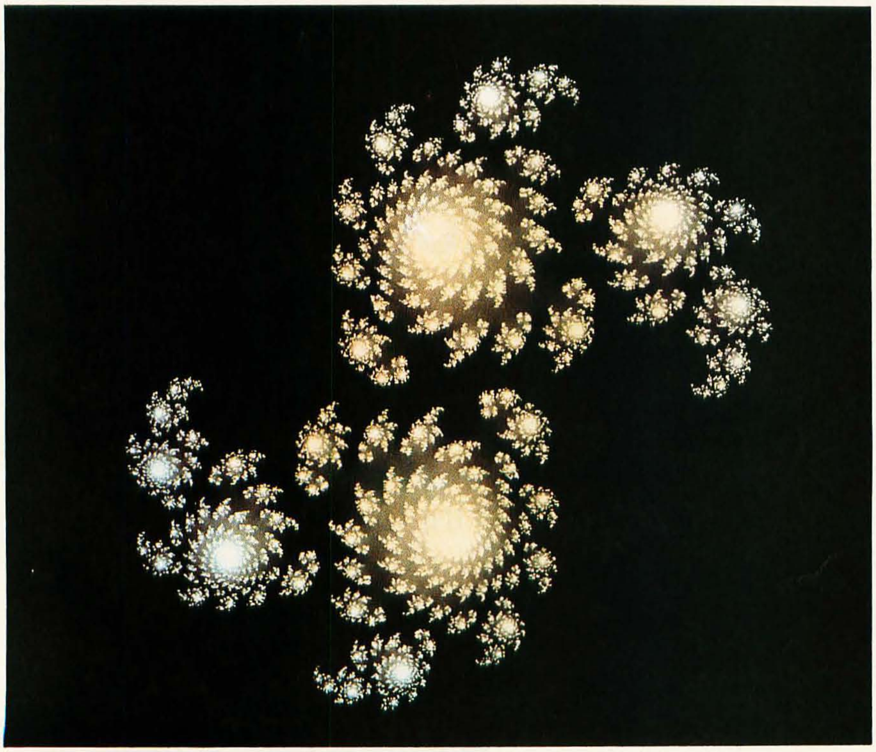

Photo 6: *"Whorls of Fractal Dust" by Greg Turk. Although a point has no topological dimension, it can have a fractal dimension between zero and one. Quantities of such points are called dust.*

The program crawls around the surface testing to see if each point is inside or outside the fractal.

formula X squared, which would give me a sphere. Other parameters can be varied to provide recurring patterns in these shapes, for example, repeating, looping strands, and lots of interconnection relationships."

His method of actually making the picture once the quaternion shape has been calculated is different from most computer graphic techniques. Instead of using polygons he builds the shapes from tiny points in space, storing their locations temporarily in memory. The resolution of the spatial grid can be as great as 1200 by 1200 by 1200 points. First, he takes an educated guess as to where the dragon is in the picture and fires a single ray at it. The place where the ray strikes the beast becomes the starting point for the rest of the process. Instead of computing the remaining points with individual rays, which would be prohibitively time-consuming, he has the program sort of crawl around on the surface of the object like thousands of ants feeling their way from point to point, checking to see if each point is inside or outside the fractal.

The lighting is accomplished with a depth buffer (random-access read/write memory that stores three-dimensional data) that requires one pass for each light source (he usually uses two or three so there will be detail in the shadows). "You're more interested in what the general reflective properties are near a point, rather than the precise reflectivity at that particular point. If you look at a real object with a fractal surface, such as the bark of a tree, it's not smooth. If you look at it real close you'll see that it's got bumps all over the place, so the light you get from it is not what you'd get from a flat surface, but it's determined instead by the average of all the little bumps together. So I pick a point on the surface and I ask 'What's the average effect of all the points near-

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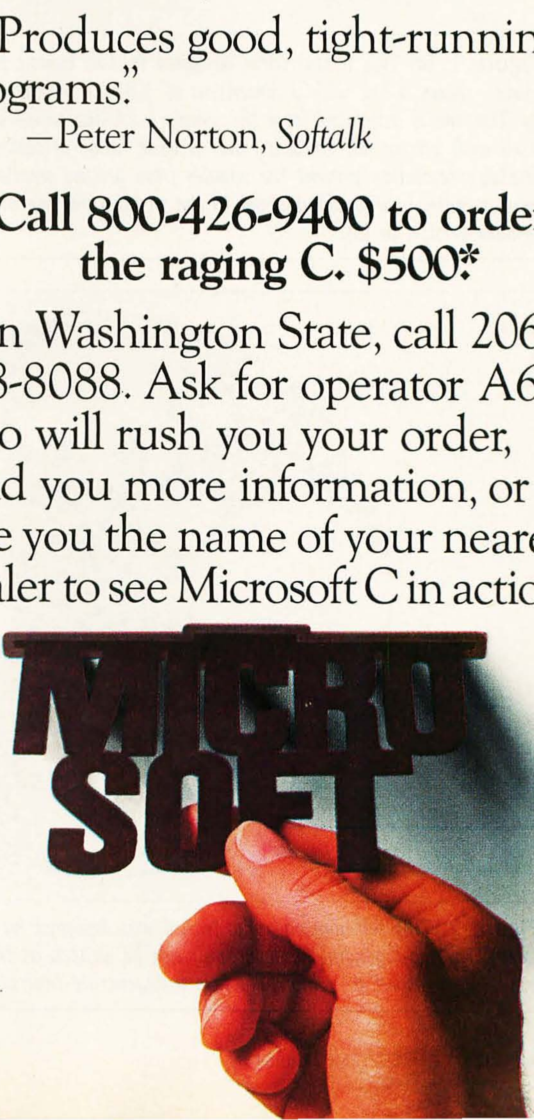

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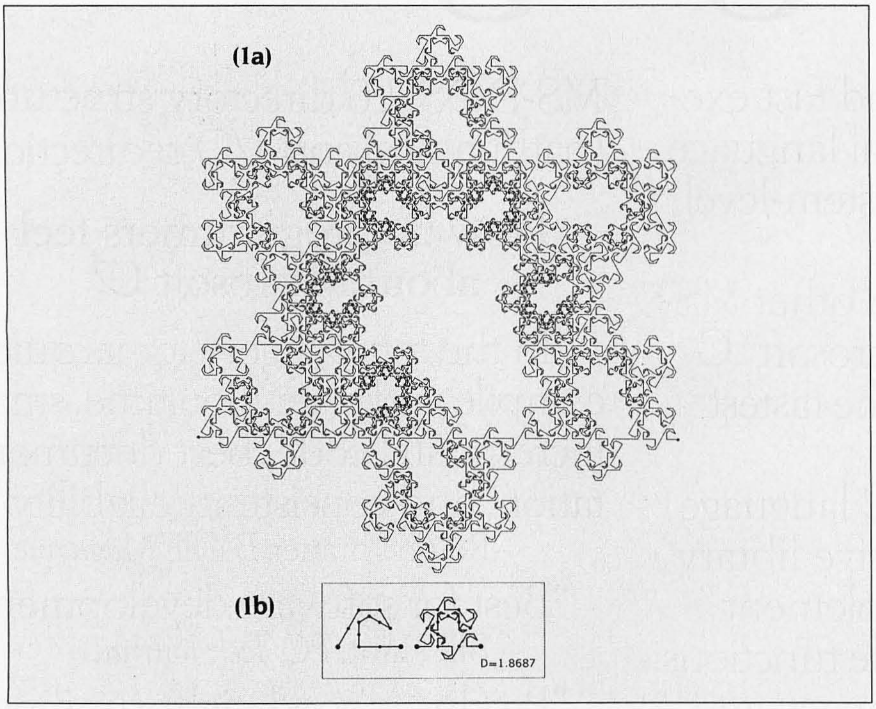

Figure 1: *(a) This fractal curve designed by* Dr. Benoit B. Mandelbrot, *"Split Snowflake Halls," shows a line with a dimension of* 1.8687 *wandering around with tortuous complexity. The line is generated from the simple hook-like shape at the bottom left, which repeats itself with precise self-similarity over a wide range of scales. Only the limitations of the display's resolution prevent the wiggles from getting smaller and smaller ad infinitum. If this were a maze, how would you get to the inside from the outside?* Hint: *try it first on the smaller version in (b).*

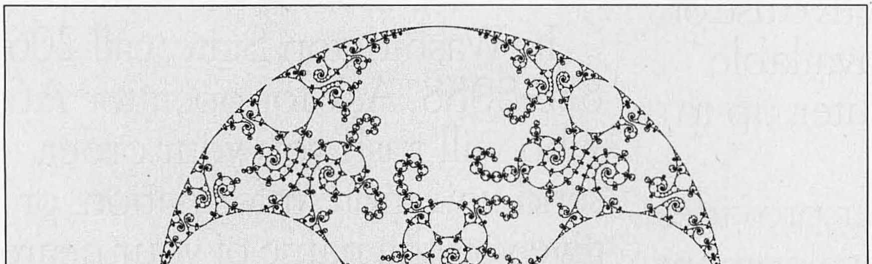

Figure 2: *This self-homeographic fractal was designed by* David Mumford. *Mandelbrot says, "The most general homeography can be written as the product of an inversion, a symmetry with respect to a line (which is a degenerate inversion), and a rotation."*

View the fractal from any angle by sorting the points by the x-, y-, and z-coordinates.

by this given point?' It's the local structure of the surface near the point in question that determines how it responds to light."

When the light values are complete and stored in the buffer, Norton can view the object from any angle by resorting the order of the points with respect to the *x*-, *y*-, and *z*-coordinates. Finally, "In order to ensure that the visible surfaces completely conceal the hidden surfaces, individual points on the model may be projected to several nearby positions in the image depth buffer. The result is a half-tone picture in which each visible point on the model produces one or more points on the picture." (See reference 2.)

The fascinating and sometimes spooky forms that the shapes take cause Norton's dragons to attract attention at computer graphics conferences and art shows. They look like plants and animals that we could easily imagine flourishing in the fertile ocean of some distant world (see photo 4). We asked him why people are so attracted to these things. "Why is it that they have such comfortable properties? They result from the simplest dynamical rules, like the rules that define the attraction between planetary bodies.

"The mysterious quality of these pictures comes from the fact that in some sense they exist. These objects have been lurking in abstract geometry and nobody's ever seen them before, but mathematically they exist just as much as a square exists and has identity of its own. You know, the ancient Greeks made a big deal about it when they discovered that the diagonal of a square is an irrational number—they thought that was such a remarkable thing that they sacrificed hundreds of cattle to the Gods and had a big party. Well, here is something that is also a fact—like the fact that the square root of two is an irrational number—but thanks to computer graphics it's something you can

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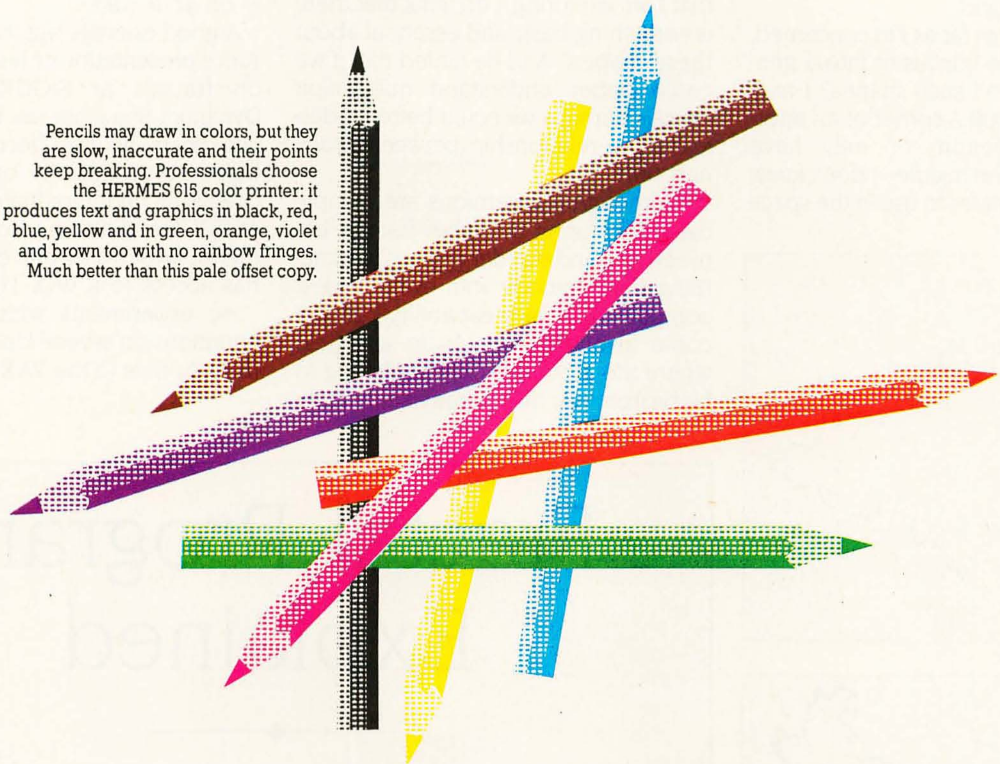

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"The mystery, as far as I'm concerned, is: how do these fractals fit into a general context of all such shapes? I may have just bitten off a corner of an enormous phenomenon, or may have landed right in the middle—I don't know the right coordinates to use in the space that I am exploring. I do think that there is something basic and essential about these shapes." And he hinted that if we could better understand quaternion fractals perhaps we could better understand the relationship between space and time.

Although quaternions are complicated, exploring the other fractals between one and two dimensions is something that anybody with even modest computer graphics capability can become involved with. As in any field where the ground is only beginning to be broken, you must forge ahead largely on your own.

A good example was 22-year-old Greg Turk's presentation of his tutorial paper on fractals at SIGGRAPH's Visual Dynamics Showcase last fall. In less than two years he has become Southern California's authority on the subject. Greg is an undergraduate math student at UCLA and also a research programmer at West Coast University, where he has access to a VAX 11/750.

He experiments with Mandelbrot's equations on several kinds of machines from Apples to the VAX (see photos 1,

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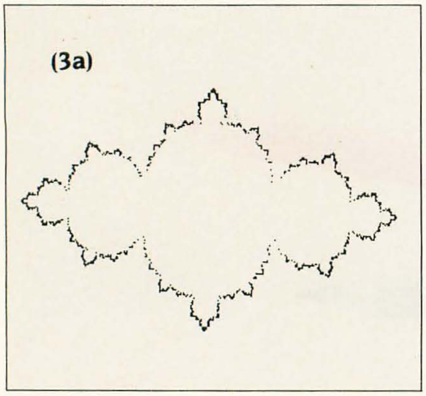

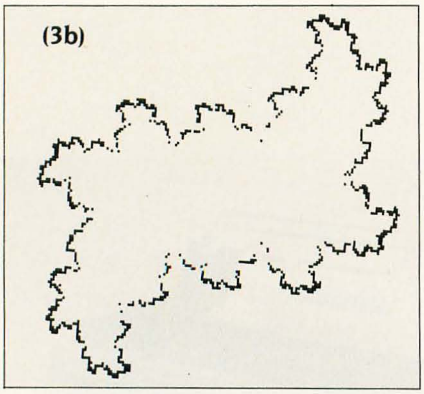

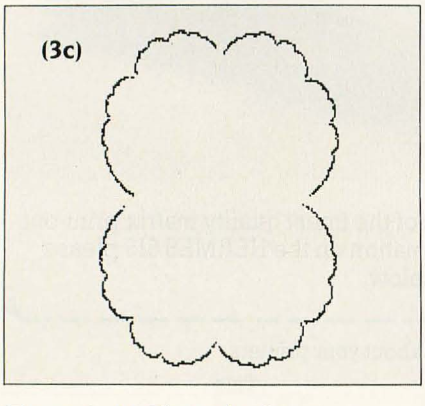

Figure 3: *(a) The result when you use lambda* = (3,0). *Notice the similarity to the first image in photo* 1. *(b) Results when lambda* = (0,1); *and you get the classical dragon curve. (c) This puffy design results from lambda* = (1,0).

Fractal Program Explained

◆

One variety of fractals results from looking at the behavior of points in the complex plane, that is, those points that are described by $x + iy$, where x and y are real numbers and i is the square root of -1. A function in the complex plane is a rule that moves a point from one position to another in the plane. It is particularly interesting to see the effect a function has on a point when that point is moved repeatedly by the same function, a process known as iteration. Even for a very simple function, the effect it can have on different points can be quite dramatic. Through iteration, a function may push one point further and further from its start, whereas another point may be kept in one area. You can draw a picture based on the behavior of the points within a region of the complex plane by giving one color to those points that are pushed away and a different color to those points that stay near their origin. It happens that, for some functions, the boundary between the different colored points is a fractal curve. A function that has been much studied is:

$$f(z) = lambda \times z \times (1 - z)$$

where *lambda* and z are complex numbers. The function takes the point z and moves it to a new point $f(z)$. The complex number *lambda* is a constant in this equation, and different values of *lambda* will result in different fractal curves.

Looking at the behavior of each point within a region can be time-consuming. A quicker way to get a rough outline of the resulting fractal curve is to look at the inverse equation; that is, have the function move the points in the opposite direction. With this new equation, you can let one point be pushed along repeatedly, and it will jump around the fractal curve. Using this method and the inverse of the above function, this program (listing 1) draws fractal curves. Since the inverse of this function results in two possible new positions for each point, the program chooses randomly at each step which new position it will use.

The program asks for the value of the constant *lambda* and, based on this and an initial value of z, it draws the position of z each time it is put through the function. The program also asks for the size of the window that the screen represents; a value of 4 is good for most pictures.

There is a whole universe of pictures you can get just depending on what number you pick for *lambda*. The only uninteresting picture you get is when *lambda* = 2; then you get a circle.

The pictures in figure 3 take about 15 minutes to compute. The reason it takes so long to generate fractals is that you have to look at the behavior of each of a large number of points within the plane.

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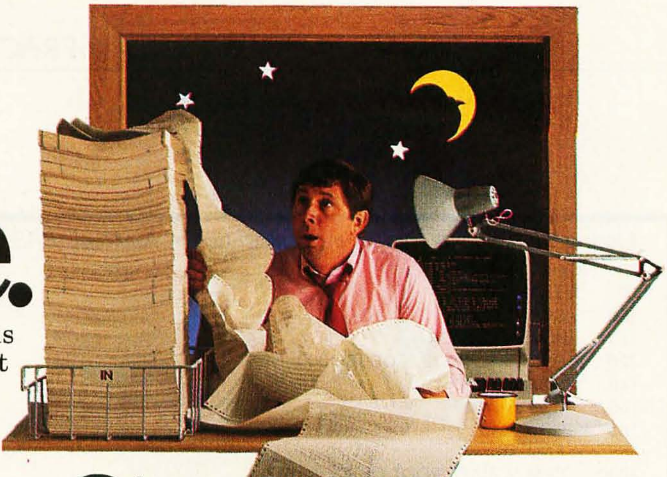

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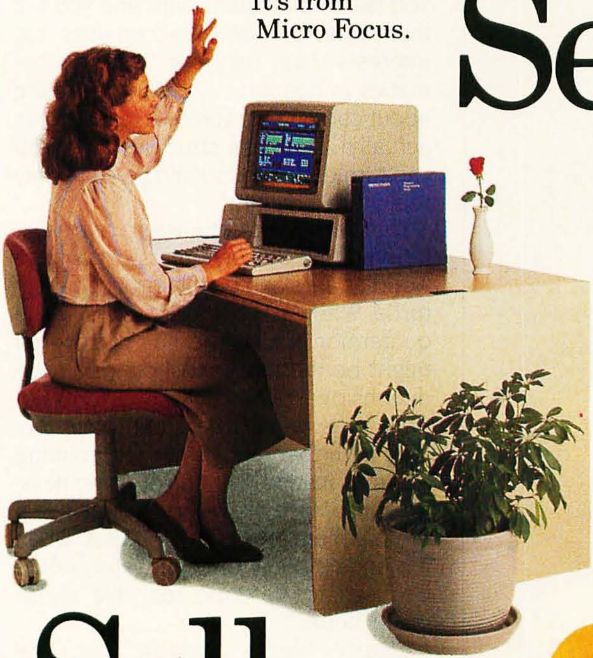

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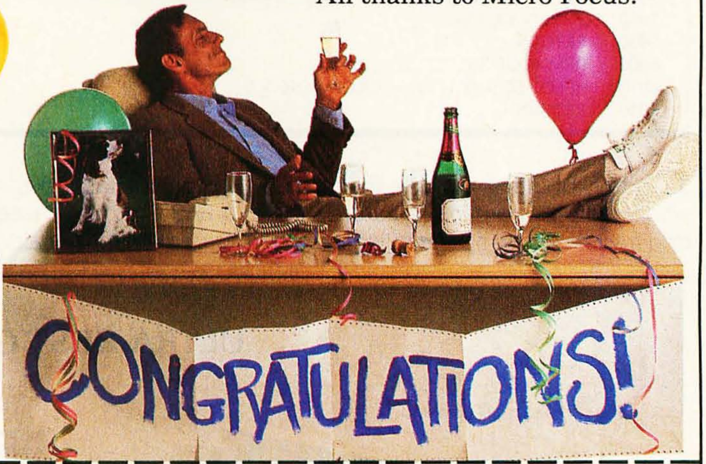

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Listing 1: *Greg Turk's fractal program written in AppleSoft BASIC.*

```
10    CX = 140:CY = 96
20    X = .50001:Y = 0
100     GOSUB 5000
110     HGR2 : HCOLOR= 3
120     FOR I = 1 TO 10: GOSUB 4000: NEXT
140     GOSUB 6000
160     GOSUB 4000
180     GOTO 140
999     END
1000    REM SQUARE ROOT OF X,Y
1005  T = Y
1010  S = SQR (X • X + Y • Y)
1020  Y = SQR (( - X +S) / 2)
1030  X = SQR ((X + S) / 2)
1040    IF T < 0 THEN X = -X
1050    RETURN
2000    REM FOUR OVER L
2010  S = LX • LX + LY • LY
2020  LX = 4 • LX / S
2030  LY = -4 * LY/S
2040    RETURN
3000    REM X,Y TIMES L
3010  TX = X : TY = Y
3020  X = TX • LX - TY • LY
3030  Y = TX • LY + TY • LX
3040    RETURN
4000    REM FUNCTION OF X,Y
4010    GOSUB 3000
4020  X = 1 - X
4030    GOSUB 1000
4040    IF RND (1) < .5 THEN X = -X:Y = -Y
4050  X = 1 - X
4060  X = X / 2:Y = Y / 2
4070    RETURN
5000    REM GET VALUES
5010    TEXT : HOME
5020    INPUT "WHAT IS LAMBDA? (X,Y) ";LX,LY
5030    GOSUB 2000
5040    INPUT "WHAT IS SCALE? ";SC
5050  SC = 2 • CX / SC
5060    RETURN
6000    REM PLOT X,Y
6010    HPLOT SC • (X - .5) + CX,CY - SC • Y
6020    RETURN
```

5, and 6), pointing the way for others who would like to explore nature's untrod fractal soil. He has provided us with a basic fractal hacker's kit consisting of a BASIC program (see listing 1) and its underlying rationale. Figure 3 shows sample printouts.

The computer, like the microscope or telescope, can make the invisible visible. Its ability to materialize mathematical abstractions—and far more than just fractals—will undoubtedly inspire a lot of people who otherwise would have been unable to appreciate such abstractions as raw textbook formulas. As Norton points out, "When you talk to mathematicians and you ask them what it is about mathematics that interests them they say 'Well, mathematics is beautiful.' . . . And the thing about computer graphics is that you can actually take these structures and you can turn them around and see that they really are beautiful."

There is an ancient Eastern representation of the Universe that portrays the world as an island on the back of a great turtle. When asked if in some sense the quaternion fractals he has discovered might be the first snapshots of a four-dimensional Great Turtle, Norton said, "The turtle may be there, but I have very little faith that that's what I'm pointing at. I may just be pointing at some passing bird. More likely this is a part of a more general phenomenon that, when it is understood more completely, could be used to describe real live things much better."

Clearly, fractals do just that. The pioneers would be pleased to see how their territory is growing today. ■

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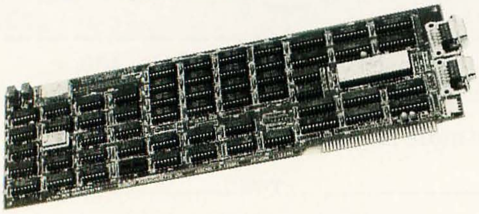
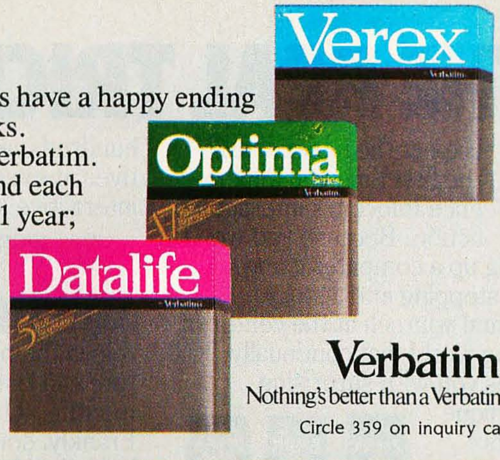
1. Mandelbrot, Benoit. *The Fractal Geometry of Nature.* New York, NY: W.H. Freeman and Company, 1982.
2. Norton, Alan. "Geometric Fractals in 3-D." SIGGRAPH. July 1982.





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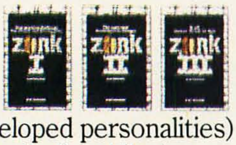

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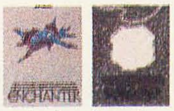

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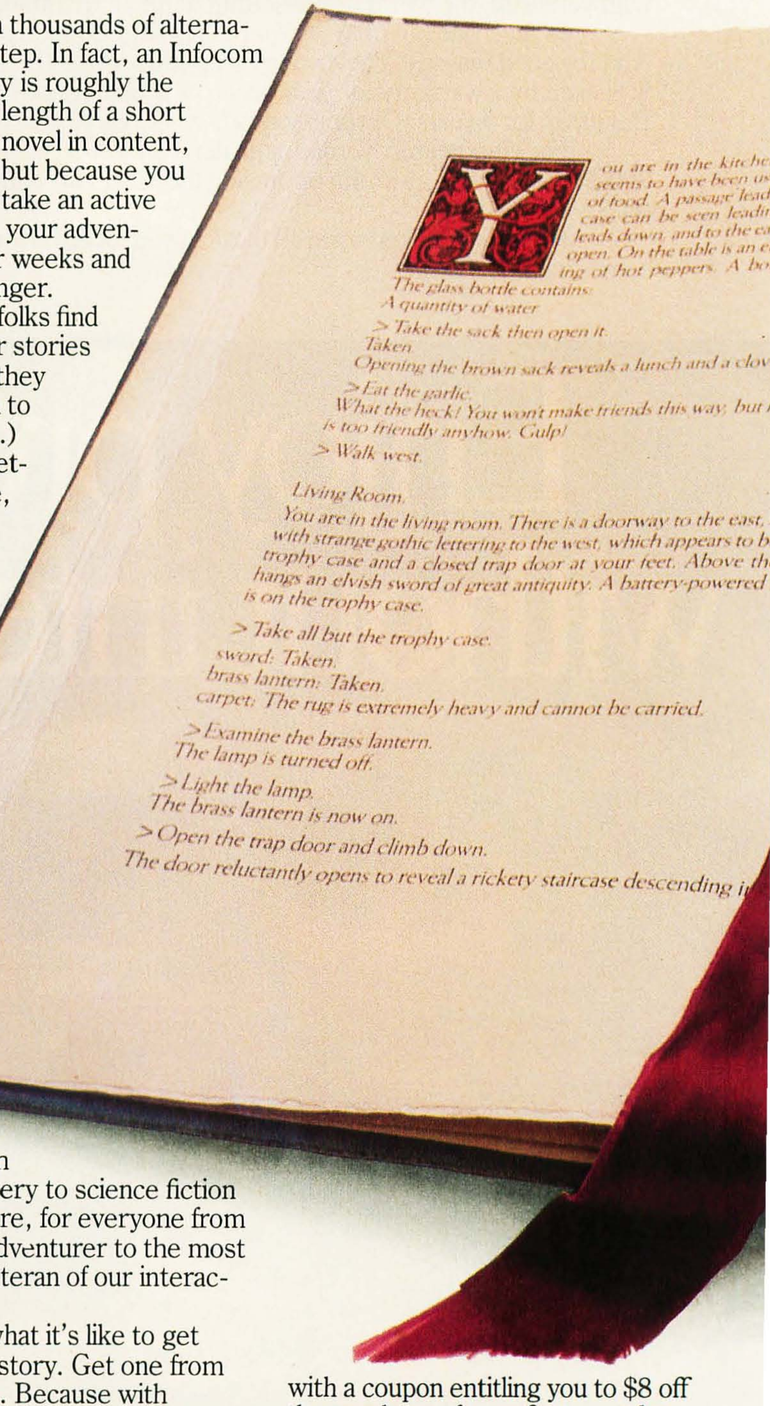

You are in the kitche
seems to have been us
of food. A passage lead
case can be seen leadin
leads down, and to the ea
open. On the table is an e
ing of hot peppers. A bo
The glass bottle contains:
A quantity of water
> Take the sack then open it.
Taken.
Opening the brown sack reveals a lunch and a clov
> Eat the garlic.
What the heck! You won't make friends this way, but
is too friendly anyhow. Gulp!
> Walk west.

Living Room.
You are in the living room. There is a doorway to the east,
with strange gothic lettering to the west, which appears to b
trophy case and a closed trap door at your feet. Above th
hangs an elvish sword of great antiquity. A battery-powered
is on the trophy case.
> Take all but the trophy case.
sword: Taken.
brass lantern: Taken.
carpet: The rug is extremely heavy and cannot be carried.
> Examine the brass lantern.
The lamp is turned off.
> Light the lamp.
The brass lantern is now on.
> Open the trap door and climb down.
The door reluctantly opens to reveal a rickety staircase descending i

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e white house. A table
ently for the preparation
e west, and a dark stair-
ard. A dark chimney
mall window which is
d brown sack, smell-
sitting on the table.

ylic.

around here

den door
d shut, a
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LASER GRAPHICS AND ANIMATION

BY JOAN COLLINS AND DOUG TUCKER

Sophisticated light effects are programmed with a microprocessor

A DOZEN or so years ago, a display of lights whirling and flashing about to the music was a common sight at a rock concert. You would often find a vapor-like display of light resembling a celestial nebula, the result of various diffraction and interference patterns of coherent light. Some artists experimented with various caustic patterns in an attempt to define light as a form in its own right, much the way a composer defines sound. And at the local Laserium show you could find a display of ethereal imagery created by similar analog techniques. From these crude beginnings an art form emerged—with a little help from technology. The medium of the laser (light amplification by stimulated emission of radiation) was born.

Photo 1: *This laser tunnel effect was created by scanning the digitized outline of the car in smoke.* © Laser Media Inc., Los Angeles, CA 1984.

The recent proliferation of 8-bit microprocessors and their peripheral devices brings the laser image into more commercial and conventional markets. (One Laser Media system is based on a Z80 microprocessor interfacing through an STD bus. Each digitizing station used to plot the points in an image has an 8080 microprocessor running on an S-100 bus system.) Today, you can find digitally created laser images at large corporate trade shows, in advertisements on television or in print, in motion pictures, live concerts, and multimedia events. Beams dance overhead in a small disco; huge figures are projected and animated on the side of a mountain; powerful lasers create dazzling effects in a variety of colors on a variety of solid and nonsolid projection surfaces. (See photo 1.) This trend is likely to continue due to rapidly expanding technology and the widening appeal of lasers.

IT'S DONE WITH MIRRORS

Incoherent light is common light in which the wavelengths radiate in all directions. Laser light is *coherent* light that is mostly all one wavelength and has all its waves traveling in one direction. The laser unit itself is a tube filled with a gas—usually argon, krypton, or helium and neon. Its ends are sealed by parallel mirrors—one fully reflective and one partially transparent. Inside the laser unit is a cathode that radiates electrons when triggered by an electric current. These electrons stimulate the gas resulting in photons that bounce back and forth between the parallel mirrors, gathering momentum until a cascade of photons exits the partially transparent end.

When the photons are out of the tube, the artist enters the process. You can project a laser on or through anything that creates an unusual effect. In the

(continued)

Joan Collins (2046 Armacost Ave., Los Angeles, CA 90025) *is a producer/designer at Laser Media Inc. in Los Angeles. She also enjoys doing computer graphics consulting.*

Doug Tucker (12000 Moorpark St., #12, Studio City, CA 91604) *is a freelance writer. He enjoys writing screenplays.*

early seventies, Ed Auswacks and Ron Goldstein, now of Laser Media Inc., experimented with beam sculpture effects, diffraction gratings, and lumia effects. For the lumia effect they shone the laser through shower glass to scatter the light. They also focused the beam on a thin piece of plastic and, as it burned through, produced underwater-like effects. At approximately the same time, Ivan Dryer of Laser Images started the Laserium planetarium show at the Griffith Park Observatory in Los Angeles. He created spiral effects using oscillators and function generators. Each one was a unique live performance, user-controlled, and choreographed to music.

In the early seventies, a laser beam and a pair of scanners were used to create a projection of concrete graphic imagery (like logotypes). Each scanner is a small high-speed precision motor-driven mirror that deflects single or multiple laser beams to trace an image several times per second. The mirrors deflect each point of the image at such a high rate of speed that they create the illusion of a solid line. These little mirror "projectors" can use any surface as a screen, including nonsolid surfaces like smoke or mist.

Glossary of Laser Terms

ANALOG SIGNALS are represented in a continuous form in contrast to digital data which has discrete values of ones and zeros.

BEAM SCULPTURE EFFECTS exist when laser beams are bounced back and forth between strategically placed mirrors.

BLANKING eliminates the unwanted connecting lines of the image.

CATHODE is the electron-emitting electrode of an electron tube.

COHERENT LIGHT is mostly of one wavelength with all its waves traveling in one direction.

COLLAPSE is the opposite of growth rate and gives the effect of the figure erasing itself.

COLOR CHOPPING is a technique that lets you assign different colors to predetermined sections of the laser image.

DICHROIC FILTERS allow certain colored lights to pass through them while inhibiting others.

DIFFRACTION GRATINGS are optical devices consisting of an assembly of narrow slits or grooves which produce spectra through light diffraction.

GROWTH RATE means that the laser displays the start/end point and one more point on each scan of the figure to give it the appearance of drawing itself out.

HOLOGRAM is a three-dimensional picture that consists of a pattern of interference produced by a split coherent beam of light which is illuminated from the rear (also by coherent light) for viewing.

INCOHERENT LIGHT is common light where the wavelengths radiate in all directions.

INTERFERENCE PATTERNS are those produced when some coherent light waves collide with others.

LASER (light amplification by stimulated emission of radiation) light is coherent light.

LOGOTYPE (also known as a logo) is a single slug or line of type cast (or traceable) in one piece, such as the name of a firm or a product.

LUMIA EFFECTS are abstract, flowing, projected effects that look like clouds or nebulae.

PHOTON is a unit of light intensity equal to the brightness of one candle per square meter.

PEG REGISTRATION occurs when one drawing or animation cell lays over the top of one or more other drawing or animation cells in precise alignment.

SCANNER is an electromechanical device that produces deflection of laser light by means of a pair of moving mirrors.

SLOW SCAN is slowing the circular movement of the laser beam to such a degree as to reveal each of the digitized points of the figure.

TRACEBACK LINE is an unwanted section of a continuous line.

The continuing need to repeat a show pushed technology from the analog mode to the digital mode. With today's computers you can digitally define a figure and program it in real time. Or you can preprogram an entire show and then let the computer execute the various complex movements and intricate color changes.

THE TECHNIQUE

Any image that you can describe with a simple continuous line—like a corporate logo—can be made into a computer-generated laser image. First you make a drawing on ordinary paper. Then, to describe your linear figure as a sequential set of x and y coordinates, you use a mouse to lay in the position of each point. The complexity of the figure and your interpretation of it determine the number of points used.

As you lay in the points, a digital-to-analog card processes the information describing the direction of the laser. The scanners receive two sets of information: one gets the vertical or y coordinates, and the other the horizontal or x coordinates. You can check the progress of your image at any time by playing back the data. The scanners then move the beam from point to point, retracing the figure. Once the figure is completely digitized, you can go back and "clean" the image to smooth out the coordinates.

Since the scanners display the image by rotating through all the given points, the start and end points must be the same to avoid an unwanted traceback line. However, you are not limited to a continuous line figure. A recent technique called *blanking* allows sections of a continuous line to drop out of view. You first define any number of sections you want blanked, and then a third scanner mirror deflects those unwanted points during each tracing.

The human eye retains light for about 1/16 second. Therefore, if you want the image to appear without flickering, the

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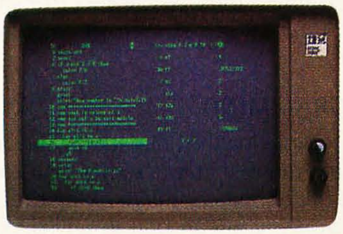

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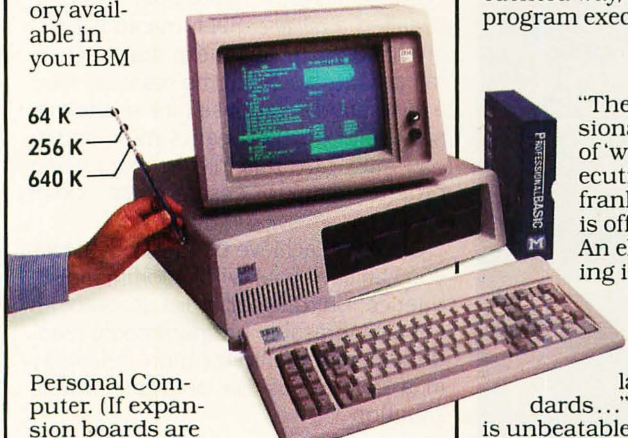

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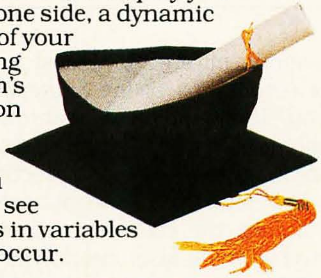

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A *laser image played the role of Tinkerbell in* Peter Pan *on Broadway.*

scanners must make at least 16 tracings or revolutions of the figure each second. Today's scanners can describe a figure of up to 850 points and still make 16 complete passes per second.

The HeNe (helium-neon) laser projects only red, the color most often associated with the laser beam. The krypton laser produces red, green, blue, and yellow, and the argon laser projects green and blue or the combination, cyan. When you need other colors, you can combine the HeNe or krypton laser with the argon laser to form one beam with any one of seven default colors. To mix or delete certain colors, you direct the combined beam through a color box with a set of dichroic filters. This filtered beam then bounces off the scanners, resulting in an image with the desired combination of colors.

Color chopping is a recent technique that lets you assign different colors to predetermined sections of the image. Used recently at a trade show advertising a cigarette, the dichroic filters changed with each scan to define a green face, blue smoke, and a red cigarette tip. This meant three color changes at least 16 times per second. Blanking eliminated the unwanted connecting lines.

To animate the image, you must repeat the entire process many times. Draw each image in peg registration as you would for conventional animation (see photo 2); then use the digitizing tablet for each frame. Create a file for each picture and load the frames into a command file on disk. Then choose an animation speed for viewing. In conventional animation you must create 12 to 24 frames per second—the more frames, the smoother the result. Due to the nature of laser projection—and of the human eye—you don't need as many frames; the eye creates the illusion of more in-between or missing frames.

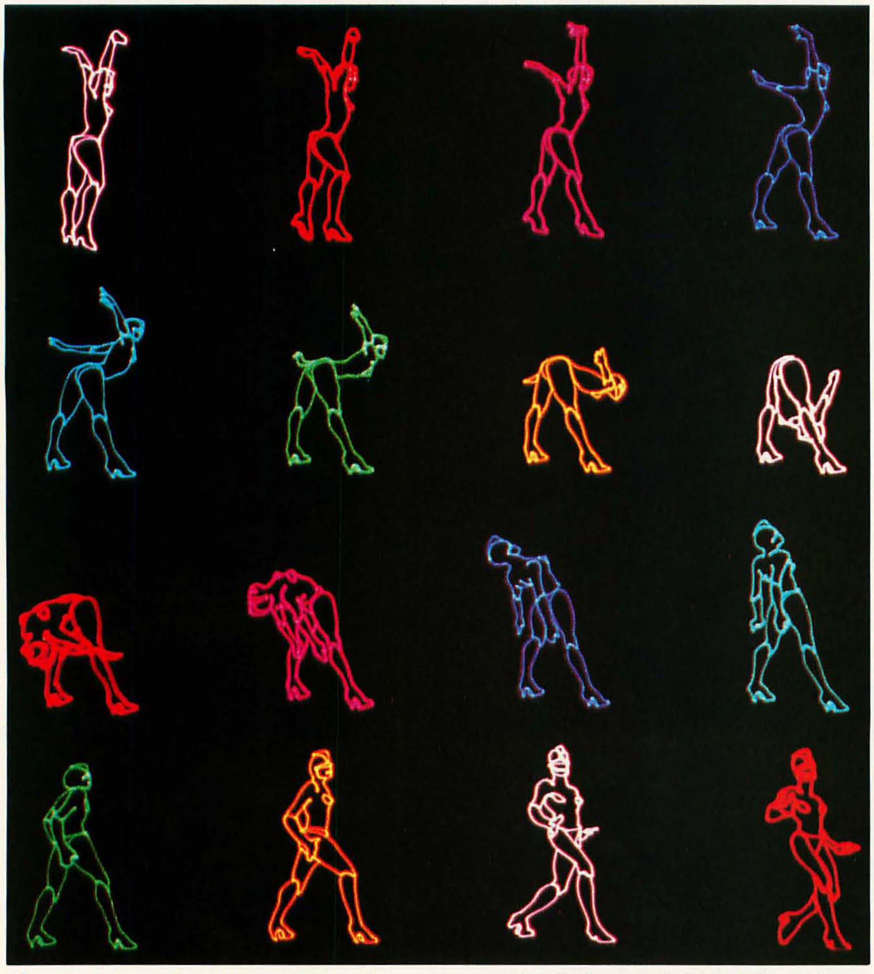

Photo 2: *Laser animation sequence showing 16 out of 450 frames of "The Robot Lady" by Michael Swofford. Each frame was entered on a digitizing tablet and then stored in sequence on disk. This example shows the seven laser colors. © Laser Media Inc., Los Angeles, CA 1983.*

PROGRAMMING

After completing the animation, you can program many manipulations. You can rotate the animated image along the *x*-, *y*-, or *z*-axis; you can pan in any direction as well as up or down in size; and you can modify the rate of scan to *slow scan*, which slows down the beam's circular movement to reveal each of the figure's digitized points. Imagine drawing a figure out point to point from beginning to end like a child's connect-the-dot puzzle. The laser displays the start/end point (point number zero) and then one additional point on each scan to give the appearance of drawing itself out. This is called a *growth rate*; its opposite, erasing the figure point by point, is called a *collapse*. Such manipulations are handled in real time in the programming stage. Note that the scanners have a measurable response time as the mirrors build up the beam's momentum; you must take this into account when programming to ensure crisp, clean images.

Once you achieve the desired effects, you can save your whole command sequence on disk or burn it onto an EPROM (erasable programmable read-only memory) chip for more reliability in a continuous-use or transportable situation.

THE LASER ON BROADWAY

A laser image played the role of Tinkerbell in the Broadway production of "Peter Pan." The jagged, quick, flutter-

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ing nature of Tinkerbell was a perfect image for the laser. Rather than using animation, Tinkerbell was a simple logo programmed with a flight path laid in using the digitizing pad. The number of points entered determined the rate of travel—many points in one place kept the figure hovering, while few points tracked a quick flight. Once the flight path was plotted in real time (with noncomputerized actors in place to work out the choreography), it was carefully digitized and stored in the computer so it could be repeated on cue nightly.

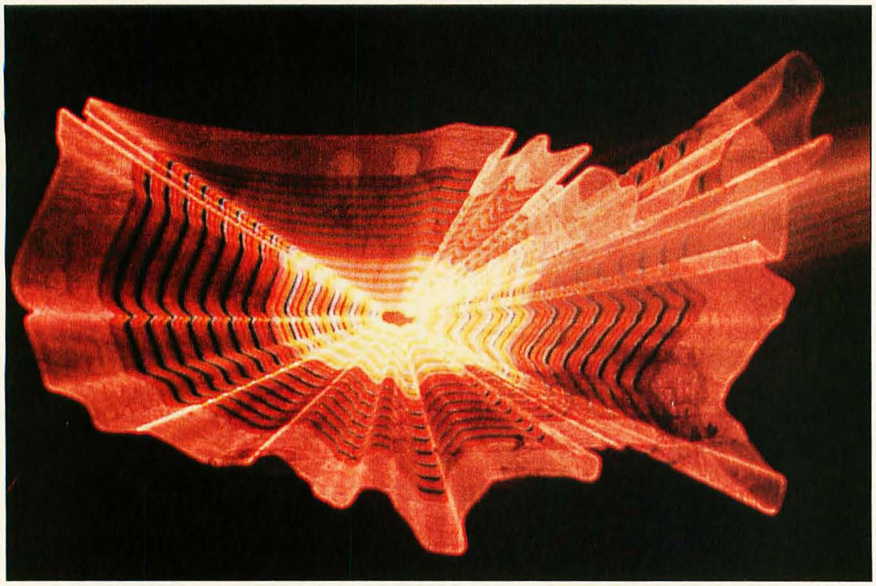

Photo 3a: *Animated laser graphics projected a thousand feet across the side of the mountain at Stone Mountain Park, Georgia.*

Photo 3b: *Huge beam sculpture at Stone Mountain Park, Georgia. The lasers and pyrotechnics are all preprogrammed and synchronized to the same time code.*

PROJECTING ON THE SIDE OF A MOUNTAIN

Conventional projection methods have limits as to size and distance. The light of even the most powerful motion picture projector diminishes rapidly in direct proportion to its distance from the projection surface. In contrast, today's laser can project an image to a far greater distance due to the nature of coherent light. For example, at Stone Mountain Park in Atlanta, Georgia, lasers animate giant images 1000 feet across on the side of the mountain over the carvings of Grant, Lee, and Jackson in a spectacle every summer. The images are as large as the carvings on this Southern version of Mount Rushmore, with the laser itself positioned over 2000 feet away. In addition, mirrors placed at strategic points in the exhibition reflect additional laser beams creating three-dimensional *beam sculpture* effects involving the audience (see photo 3a). On top of this there are pyrotechnics preprogrammed and synchronized to the same time code as the lasers (see photo 3b). Another use of high-powered large-scale projection, although smaller than the mountain, was the laser billboard this summer during the Los Angeles Olympics. The side of a Westwood building displayed public service announcements, traffic reports, Olympic news, and, of course, sponsor logos. Kinetic laser billboards may create a new high-tech adjunct to the advertising industry—and probably a few traffic jams.

ALTERNATE PROJECTION SURFACES

Laser light by its nature produces a projection that seems suspended in midair, viewable from all sides. Holograms, using laser light, are a prime example of this three-dimensionality. This year the concert tour of the rock group "Yes" treated its audiences to a clever light show. In the finale, lasers began to shoot what appeared to be graphic holograms into the air. The scanners projected a graphic image onto a unique projection surface—inconspicuous, loose-woven, black bobinette material—suspended over the stage. Animated rotations of the image created the illusion of depth.

Laser images projected in a room full

(continued)

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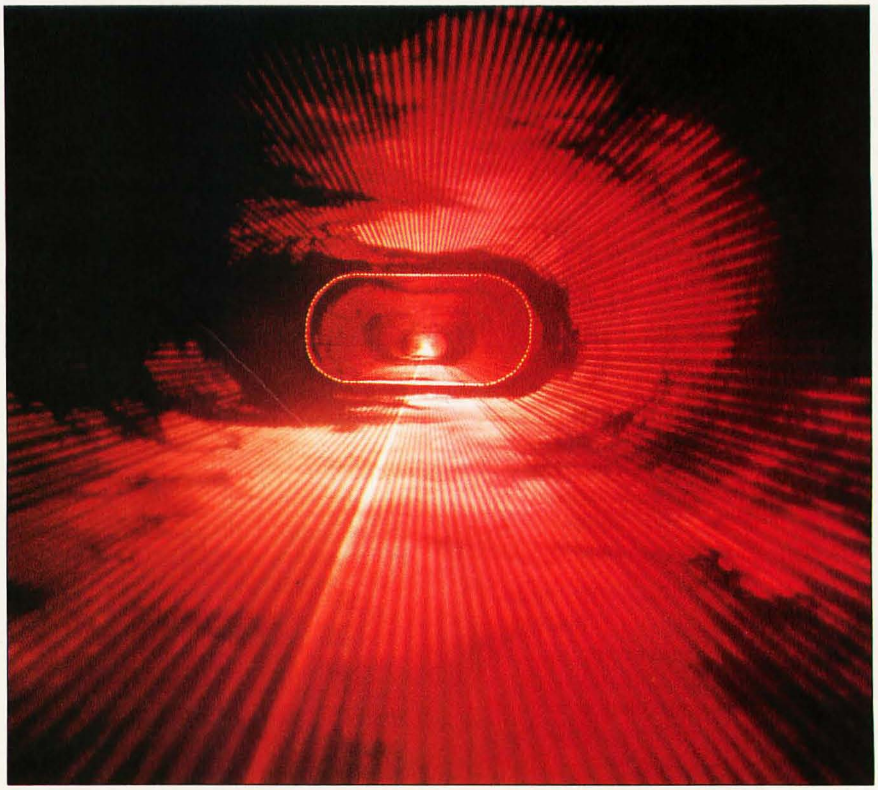

Photo 4: *Digital tunnel showing actual points of light reacting with smoke.* © *Laser Media Inc., Los Angeles,* CA 1984.

of smoke also create a sensation of depth. The smoke particles provide many projection surfaces rather than one solid target. The beam is visible throughout its travels, which gives the sensation of a tubular graphic suspended in space. This technique also works well with beam sculptures, where laser beams are bounced back and forth between strategically placed mirrors. And you can create a three-dimensional tunnel effect by having the scanners describe a circular graphic image (see photo 4).

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The largest and most powerful entertainment laser installation in the world to date is now on view in Florida at the EPCOT Center. Each evening the closing entertainment, "Laserphonic Fantasy," features five computers driving six lasers and eight sets of scanners—all synchronized within 0.01-second accuracy. Four sets of scanners float on barges in a lagoon and project over 1000 kilobytes of graphic imagery into water screens. The fine spray of water is barely visible at night, leaving the laser graphic to appear to float in three dimensions.

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"The main limitation is in the scanners," says Paul Rother, software engineer with Laser Media. "Of course, as we continue to get faster scanners to work with, the graphics will become much more complex." Today's laser images are certainly more sophisticated than the abstract patterns produced a few years back. Tomorrow's images will likely show a similar advancement. For the present, however, it is interesting to see how creative and complex we can be with lasers that are programmable with a microprocessor. ■

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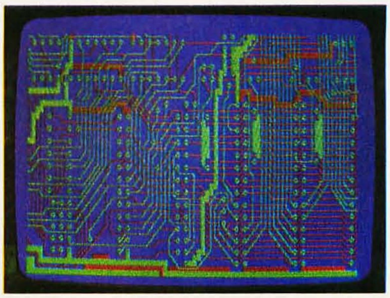

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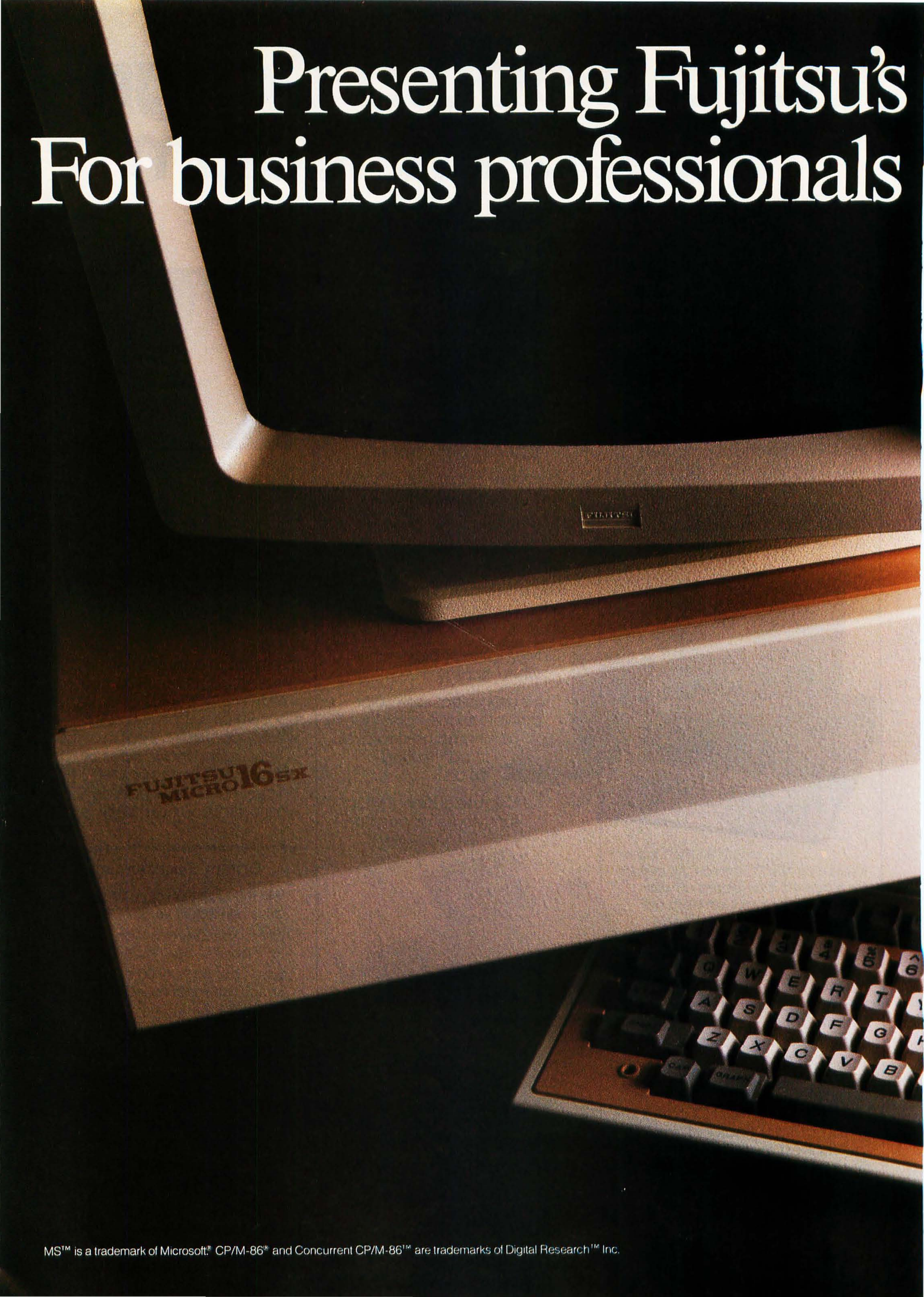

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THE COMPUTER AS AN ARTISTIC TOOL

BY ISAAC VICTOR KERLOW

The imaging process does not change, only the medium does

SINCE MAN FIRST used simple tools to scratch pictograms on the walls of caves thousands of years ago, imaging technologies have evolved a great deal. Artists throughout history have used painting, photography, and other techniques to create illusions of space and time—to push the imagination to its limits. Today you can use computers to dazzle your senses with colored lights.

The computer is, in the opinion of many, too cold and technical to be involved in artistic creation. Similar prejudices about technology arose in the past century when machines were introduced on a massive scale into both the industrial and everyday worlds. Most people distrusted the mechanical monsters until they got used to them. The impact and influence of computers on the imaging process today are similar to those of photography in the 19th century (see reference 8). Miniature painters and engravers feared that the camera would replace them and even called it the invention of the devil.

Since the fifties, computers have been used to create images, but the first artistic experiments didn't take place until the early sixties. The nonartistic applications of computer imaging systems, such as real-time flight simulators, computer-aided design and manufacturing systems, and image processing of remote sensing data, are more familiar to computer users because they are widely used. However, the artistic applications are relatively unknown. *Computer art* refers to those works created with the aid of computer-based tools and methods for the purpose of fulfilling an aesthetic need in the creator as well as in the public.

I will outline the methods used to create computer art and the general concepts behind it, focusing on images of three-dimensional environments and objects created by mathematical models or databases—particularly those described first in a three-dimensional space and then on the surface of a two-dimensional medium like a raster monitor screen or a sheet of paper. This article does not cover two-dimensional techniques for the creation of computer-generated images. For further details on the procedures and algorithms mentioned, you should consult the classic reference works (see references 4, 12, and 14).

THE EVOLUTION OF COMPUTER ART

Most early computer art was created not in art studios but in research laboratories, and many of the first computer artists came from fields like the exact sciences and electronic engineering. Nevertheless, they had some sort of artistic intention, some degree of aesthetic consciousness. The computer systems they used were not designed for artistic creation and, consequently, were not adequate for it. They were not very interactive—or not interactive at all—and the machine-user interface was

(continued)

Isaac Victor Kerlow (26 Gramercy Park South, New York, NY 10003) is a freelance graphic designer and animator for Byron Preiss Video Productions, a video game producer, and for Digital Effects, a computer animation company. He also teaches a seminar on digital typography for microcomputers in the Computer Arts Forum. He received a B.F.A. in graphic design from the School of Visual Arts in New York and an M.S. in communications design from Pratt Institute. His work has been exhibited widely and has appeared in several publications.

cryptic, opaque, and difficult to understand.

Many of those creators of computer art had to put more effort into the execution of their works than into the creative process itself since communication with the computer was so hard to establish. Although they became more concerned with developing computer-based imaging tools than with artistic style, they did make effective use of the available technology despite its limitations.

Their creations constitute the first products of a technology still under development. Early computer art was uniform and simple; its style was largely defined by the limitations of the available equipment and by the lack of programs capable of rendering complex images. Complex methods and data structures did not always yield correspondingly complex images. A language of simple two-dimensional geometric elements remained for a long time as the visual trademark of computer art. John Whitney Sr., Charles Csuri, and Kenneth Knowlton are among the American pioneers of computer art (see references 10 and 15).

The panorama of computer art changed greatly during the seventies with the development of techniques for representing three-dimensional environments and the increased involvement of full-time artists. Computer-based imaging systems became more interactive and easier to use. Many artists who became interested in computer technology began using it as their primary medium for artistic creation and contributed to the technical development of computer-imaging tools.

Recent computer art is complex and full of various styles, techniques, and attitudes. It is not yet entirely mature, but already it encompasses an exciting body of work. Its creation is becoming an increasingly specialized field requiring a great number of interdisciplinary skills.

THE CREATIVE PROCESS

I have worked with other imaging techniques for more than 10 years, and I find that creating an image with a computer is similar to the creative process other technologies follow. The main differences are not so much in the creative process as in the tools and how they are used. Most artists know how to create images but not how to use computer-based tools and methods. Therefore, it is important that these tools be easy to operate and that the user-computer interface be properly designed.

The tools of computer art are very different from the artist's traditional tools. They include the computer itself, the programs driving it, and the input and output devices controlled by it. The type of creative work done is dependent on the computer's various capabilities. The programs contain the procedures needed to create the images. The input and output devices collect the creative information and generate the final image and, therefore, should be especially easy to control.

The creation of computer-generated art is not a simple task. Besides the aesthetic problems, you often encounter difficult technical problems, and

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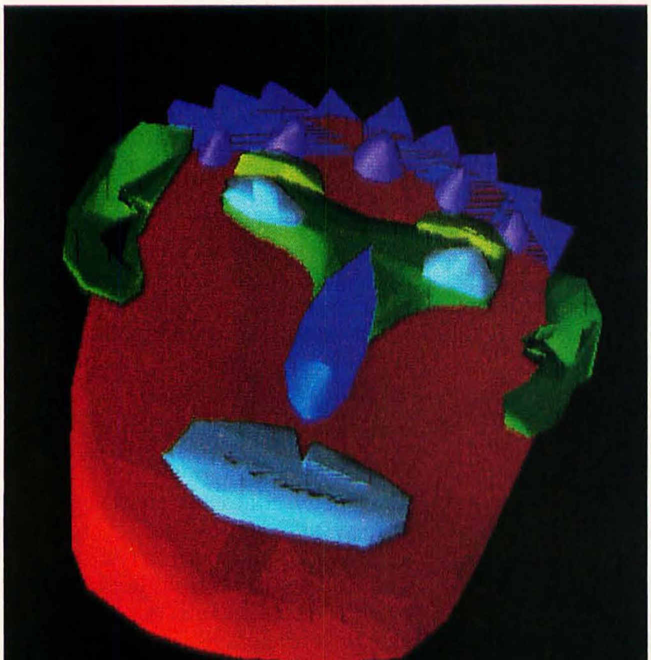

Photo 1a: *Front view of "Mask.1," a three-dimensional object with hidden surfaces removed and rendered with smooth shading. The mask is made of 16 simple pieces assembled together (a total of 858 polygons) and was digitized from freehand drawing. All images are copyright © 1984 Isaac Victor Kerlow.*

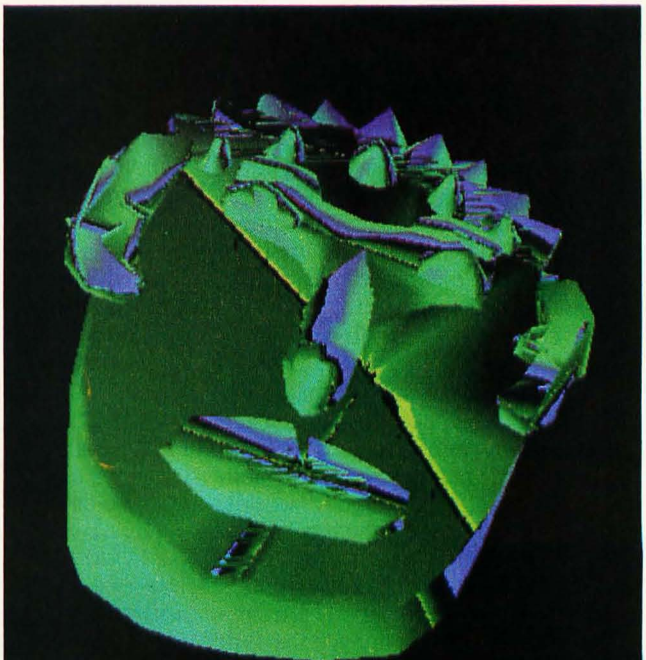

Photo 1b: *Another version of "Mask.1" rendered as an opaque surface (with a model of diffuse light reflection) and colored with color lookup tables to simulate a shiny surface (specular light reflection).*

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The CARTOS *system has been implemented on* DEC PDP-11/05, LSI-11/02, PDP-11/34, PDP-11/45, *and* VAX-11/780.

many of the systems available for creating images are imperfect. A direct correlation exists, though, between the operations that artists traditionally perform to create images and the operations described by the computer's programs. In fact, many of the methods have been borrowed from other technologies. In principle, if you already know how to create images, you should find it easy to learn one more method for doing so. Nevertheless, that learning process involves, among other things, many hours going through thick user's manuals. There are pluses and minuses. If you work with a computer, you can use its unique features but you must also accommodate your work to the limitations of your particular system.

Each of the several ways to create a computer-generated image has its advantages and its limitations. You can divide the process of creating a three-dimensional shaded image into several stages: image conceptualization and design, database creation and editing, procedure rendering (hidden surface removal, lighting and shading, and color and texture creation), and final output production (see photo 1a).

A number of these procedures require considerable amounts of memory and computing power. Traditionally, such procedures were implemented exclusively on large- or medium-size computers. Today, you can successfully implement many of them on some of the new and powerful 16-bit microcomputers. In any case, the various stages of the creative process remain basically the same regardless of the equipment that you use.

THE COMPUTER SYSTEM

Although I have used several computer systems for creating images, I have done much of my experimental work with one particular system, the CARTOS system (computer-aided reconstruction and tracing of serial sections). Researchers at Columbia University have been developing this system since the seventies. CARTOS was not designed to be an artist's tool but to help biologists see complex microscopic elements in three dimensions. It can reconstruct and simulate three-dimensional objects from two-dimensional data obtained from light and electron microscopes. The system can accept manual or automatic input and can reconstruct almost any series of cross-section images (see references 2 and 9).

The CARTOS system has been implemented on almost the entire family of DEC computers: PDP-11/05, LSI-11/02, PDP-11/34, PDP-11/45, and VAX-11/780. The current version runs on a VAX-11/780, and a simpler one is being implemented on two 16-bit microcomputers, the Codata 3300 and the Onyx C8002. You can direct the visual output of the system to a Grinell 270 color raster monitor, to an Evans & Sutherland Picture System II vector monitor, and to various hard-copy devices including a plotter and a black-and-white electrostatic printer.

Written in C, the software includes almost no assembly-language routines and runs under several versions of the UNIX operating system. Since C has no built-in graphics capabilities, CARTOS uses several in-house programs and subroutine libraries. It also uses various UNIX library routines that are not identical in all UNIX systems. Since the largest program requires only about 100K bytes of main memory, you can transport slower versions of CARTOS to smaller systems.

You cannot call the CARTOS imaging programs state-of-the-art, but they are flexible and extremely effective. They include input, editing, hidden-line removal, shading, and coloring routines. Many of its three-dimensional interactive functions are similar to those in the GSPC Core System (Graphic Standards Planning Committee, see reference 6). Its rendering program is based on the Raster Test Bed developed by Whitted and Weimer at Bell Laboratories (see reference 16). The *test bed* is a set of utility routines used to display three-dimensional shaded images on raster scan systems. You can merge these routines with a variety of user-defined techniques but only under two conditions: (1) you must express all surfaces as polygons before you can display the final image, and (2) you must convert the data to the proper description format. The basic elements of the test bed are a transformation and clipping module, a scan-conversion processor, and a shader. The CARTOS version stores all the polygons before performing the scan conversion and produces a 512- by 512-pixel monochrome image file with smooth (Gouraud) shading.

CONCEPTUALIZATION AND DESIGN

Conceptualization and design form the first stage in computer image creation. From an artistic point of view, this step is the most decisive because you must lay out the basic characteristics of the image, analyze your basic ideas, and describe them in visual terms.

It is helpful to prepare the initial sketches describing the objects and their environments traditionally, with colored pencils or markers on paper. These sketches contain such general characteristics as size, relative position, color, and lighting. Once you finish the sketches, you must analyze them and break them down into a series of contours. You can describe these contours in detailed blueprints suitable for digitizing. The blueprints show your three-dimensional objects in a two-dimensional cross section; drawing them on grid paper makes the marking of numerical coordinates easier.

I often draw my blueprints freehand so that the final object looks somewhat handmade. I also draw two views: one for digitizing and the other to help me visualize the object better (see figure 1). The first view contains vertical and horizontal information (x- and y-coordinates), and the second, depth information (z-coordinate). Some objects are more easily described by horizontal cross sections and others by vertical.

THE NUMERICAL DATABASE

A numerical database is necessary to model the objects that appear in the final image. Many methods are possible to translate the visual information contained in the sketches into formatted numerical information suitable for computer manipulation; among these are digitizing, mathematical description,

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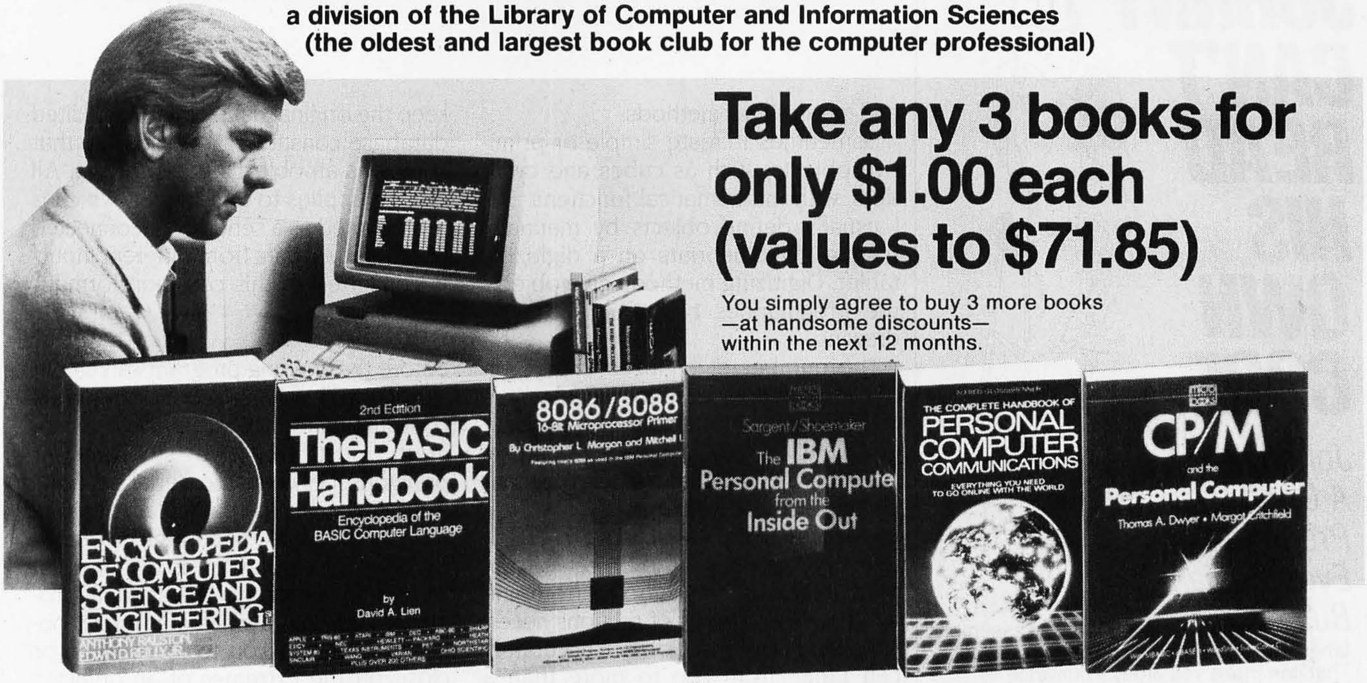

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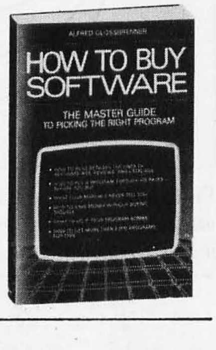

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and procedural methods.

Sometimes I create simple or primitive objects, such as cubes and cylinders, with mathematical functions. But I usually define objects by manually tracing my blueprints on a digitizing tablet. Digitizing methods give objects the irregularities typical of freehand drawing.

The number of digitized cross sections needed to describe an object is directly proportional to the complexity and detail of the final object. The sections on the *x* and *y* planes represent a sample in the horizontal and vertical levels of the original object. An *aliasing* effect can appear if the object is sampled at large intervals too far from one another. The number of sections necessary to describe an object accurately can range from two to more than a hundred.

Once you have digitized all the contours, editing the database lets you reaccommodate individual sections or entire objects in three-dimensional space. You can perform such geometrical changes as scaling, rotation, and transformation to modify relative spatial positions. The editing program stores the coordinates as integers to reduce memory requirements and records all scale-related information separately to keep the original data intact. The edited database constitutes a master file that serves as an object's basic format. All editing applies to this format, which is represented as a series of unconnected contours. (All data from different inputs is converted to this common format.)

SHADING

Before the shading program can create surface and volume around the initial contours (see photo 2a), another program must create a structure of polygons between the serial sections (see photo 2b). The particular *polygonization* program I use generates its output on a vector display or as a numerical format acceptable to the shading program. It also has a switchable *capping* option that allows you to leave open or close off the extremes of an object.

The shading program accepts spatial position instructions before it generates the shaded display. During computation it puts out alphanumeric information on a secondary monitor about the number of polygons, vertices, and edges involved in the image and the number of active pixels in the frame buffer.

CARTOS's surface-rendering program works best on simple spheroid or elongated structures. It cannot properly

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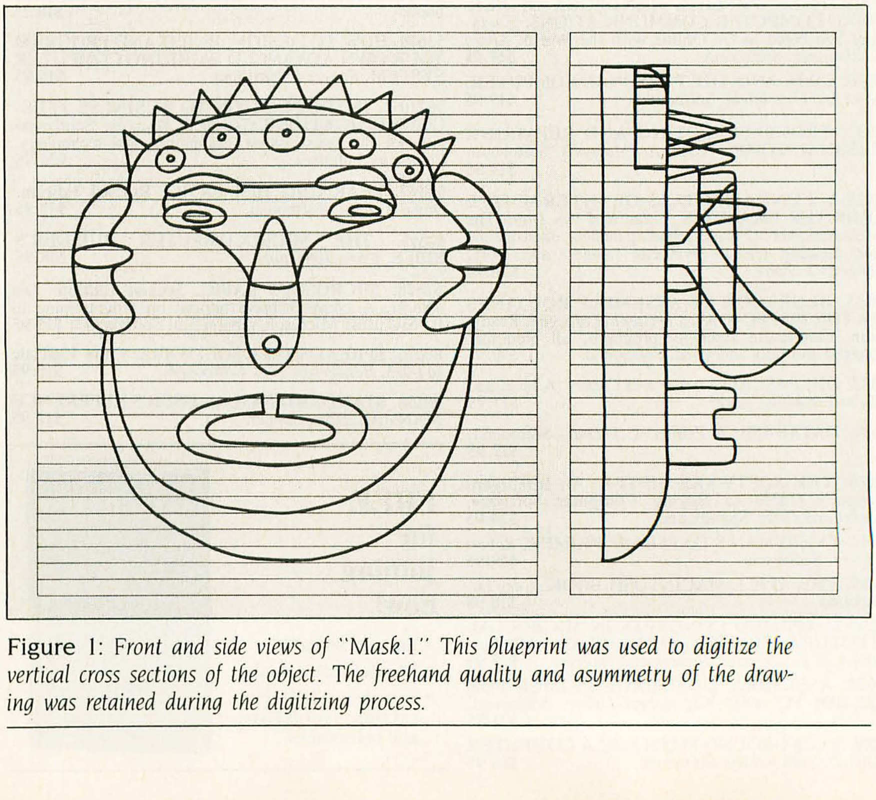

Figure 1: *Front and side views of "Mask.1." This blueprint was used to digitize the vertical cross sections of the object. The freehand quality and asymmetry of the drawing was retained during the digitizing process.*

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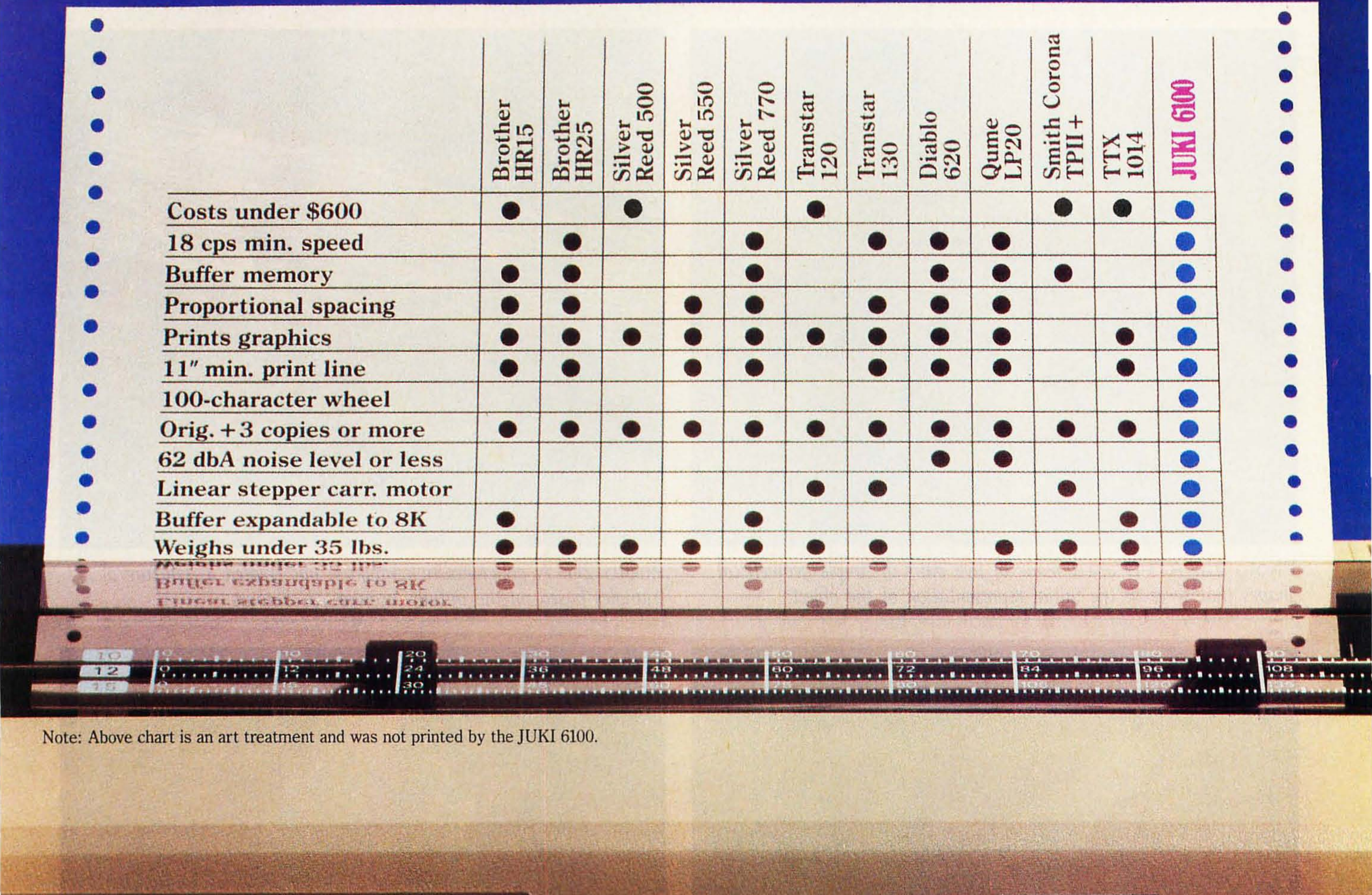

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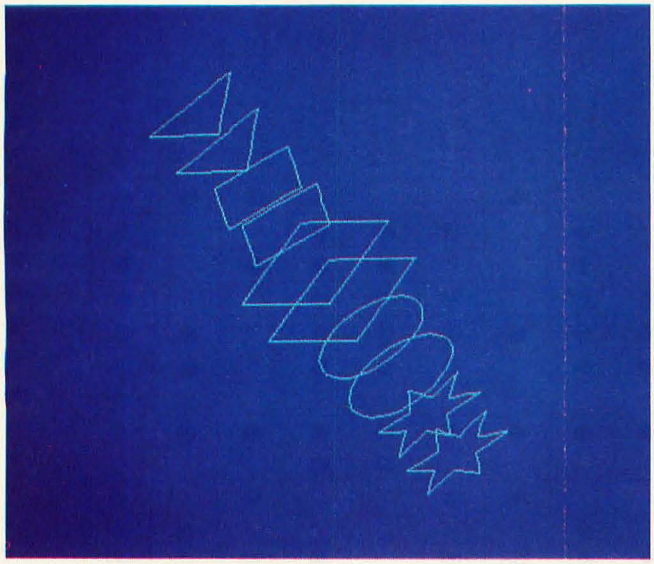

Photo 2a: A 3-D *object made of five pairs of simple geometrical shapes that serve as the initial representation of the object.*

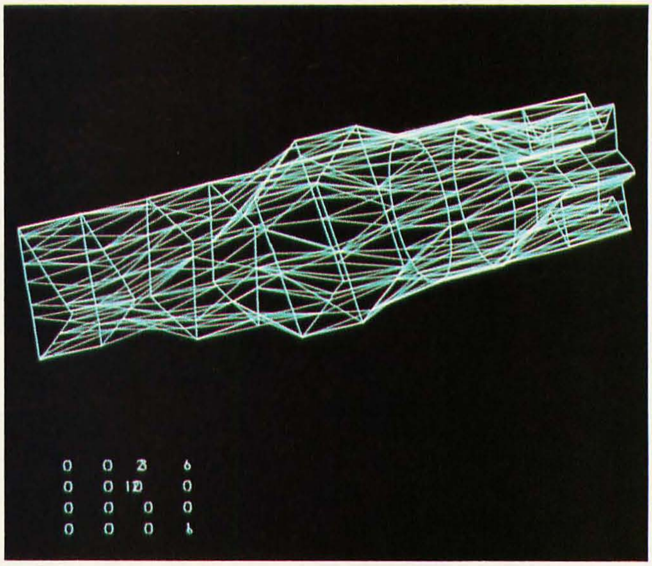

Photo 2b: A *polygonization program has created a structure of triangles based on the initial unconnected contours.*

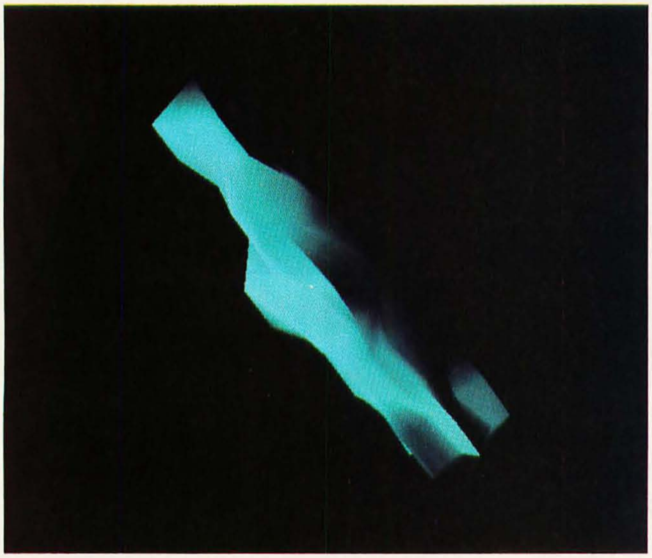

Photo 2c: *The five pairs of geometric shapes rendered as a monochrome solid object with smooth shading.*

Photo 2d: *Two objects concatenated to form "Colorful Trap."*

handle objects with zigzag shapes, concave surfaces, or acute angles. Therefore, when you want these characteristics, you must use alternate methods. One way to describe complex objects correctly is to render them as *uncapped* three-dimensional contours. The shading program uses Gouraud shading to produce smooth connections between polygons through normal linear interpolation. The lighting model uses a single light source and simulates the diffuse reflection of light typical of opaque surfaces (see photo 2c). Another way of handling extremely irregular objects is to divide them into several simpler objects and then reassemble them with a concatenation program. You can also assemble groups of simple objects into one composite object (see photo 2d).

COLOR

After shading, to color the final object I usually use color lookup tables. Several approaches are possible for manipulating these tables, each yielding different results.

The concept of color lookup tables is closely related to the way the frame buffer works. A frame buffer is an area of main memory dedicated to storing and manipulating raster images. It can hold an image or frame resulting from different computations and data transformations. The word "frame," from the language of film, refers to the individual frames, or images, on a strip of

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film. Frame buffers are two-dimensional arrays of different sizes, usually with several bit planes. Each pixel, or picture element, in the final display has its corresponding address in the frame buffer that the display controller reads before generating an image on the raster display.

You can configure frame buffers in several different ways. The simplest one has a single bit plane whose output values create a monochrome image. (With one bit plane you can generate only two intensity levels: black and white, or 1 and 0 in binary; in other words, 2 to the power of the number of bit planes equals the number of intensity levels.) As you add more bit planes, you can display more intensity levels. For example, a frame buffer with three bit planes can display 2^3, or 8, intensity levels while a frame buffer with eight bit planes can drive the color guns inside the monitor, either directly or through color lookup tables. I created the images that illustrate this article with a frame buffer containing 512 by 512 by 8 bit planes driving the color guns through three 8-bit by 256-byte lookup tables (see figure 2).

Color lookup tables contain a collection of values that you can access with the numerical output of the bit planes. The intensity value of a pixel "looks up" the numerical color value stored in a specific location in the lookup tables; this value then drives the RGB (red-green-blue) guns at its particular intensity. The lookup tables provide a cheap and simple way to obtain a great variety of colors with limited frame-buffer memory.

You can easily determine how many colors you can generate with various-sized frame buffers and lookup tables. The total number of possible colors available for display, that is, the palette, equals $2^{(3 \times w)}$, where w represents the width of the lookup table in bytes. The number of colors that can be simultaneously displayed on the monitor equals 2^n, where n is the number of bit planes.

(continued)

The Controversy in Computer Art

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The production of *the* original is one of the most controversial issues in computer art. It is so controversial, in fact, that it is largely responsible for keeping computer art from being officially accepted as a major visual art, from being recognized as a valid medium for contemporary artistic expression. The production of the original is relevant technically and aesthetically as well as for economic and marketing reasons, and it is worth examining in more detail.

For centuries the visual arts have produced a unique object that is considered an original, a final work that exhibits the completed image (e.g., a painting on a canvas). The number of ways you can enjoy a computer-generated work adds many variables to the question: What constitutes the original work in computer art (e.g., a photograph of the computer image, interactive displays, real-time animation, and so on)? You can find new answers by looking at the nonvisual arts. In many forms of artistic expression, the original is not necessarily limited to a single object. What is the original in a musical creation—the score, the performance, or the recording?

Computer-generated images follow a script or a program, and you can recreate or perform them at different times. Moreover, you can easily animate computer-generated images by displaying and recording them in sequence and build them in real three-dimensional space.

The issue of the original in computer art also brings up the relation between art and technology, the identity of the artist, and the visual language used. Understanding the relation between art and technology is necessary to understand the aesthetic values of computer art. Throughout history different technologies have contributed tools and methods for the development of artistic projects. Artistic creation in the Renaissance period would not have been possible without the technology for fabricating colored pigments, brushes, or canvases. Without the technology for recording images photographically, many of the events that occurred at the turn of the century would have gone unrecorded. Computers are the latest entry in the historical development of imaging technologies.

A unique blend of computer tools and artistic methods, including electronic hardware and imaging programs, makes the existence of computer-generated images possible. Perhaps the day will come when intelligent computer systems will provide us with computer-based imaging software capable of developing a style of its own. For the time being, however, the computer is only a tool.

You don't need to be a systems programmer or an expert in mathematics in order to create computer art. However, you have to understand how both the equipment and the programs work, especially if you want to enhance your creative tools. You must use computer technology to develop a consistent body of work with individual aesthetic and stylistic values. And you cannot consider all the images you create to be art. Computer art, like any other, only emerges from dedication and a sharp aesthetic consciousness.

No rules determine what computer art should look like. You develop this language as you develop your work. In my opinion, computer technology should create images that cannot be made with any other imaging techniques, not just mimic those in other media.

The computer pushes artistic imagination in new directions. We should use its tremendous creative flexibility to explore all types of form and content, from hyperrealist scenes to random abstract structures. The development of a visual language specific to computer art is more related to the artist's attitude than to the type of equipment in use. You can create beautiful works with simple or sophisticated equipment. The amount of computing power you need becomes a problem only if you want to produce extremely realistic images on a massive scale.

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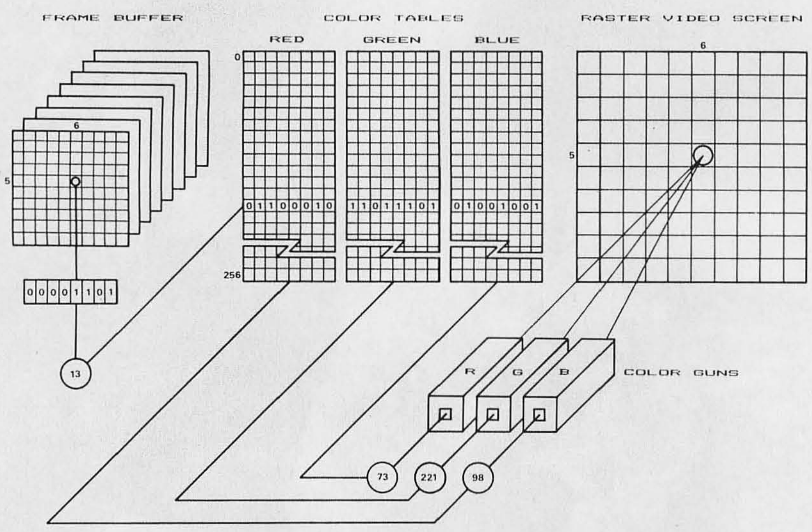

Figure 2: *Configuration of a frame buffer or video-display memory with eight bit planes driving the* RGB *color guns through color tables 8 bits wide by 256 bytes long. The dimensions of both the frame buffer and the raster video screen have been simplified in this diagram for clarity.*

Table 1: *Color aliasing effects can be created by manipulating the color lookup tables. The color red is located between bytes 32 and 48 in this example. The table on the left will produce an orange color and the table on the right will produce an orange pattern. The data in the left table creates a smooth gradation of intensities. The data in the right table creates a stepped gradation that goes from white to black several times.*

PARAMETERS	R	G	B	PARAMETERS	R	G	B
Color table	0	1	2	Color table	0	1	2
Starting at byte	32	32	32	Starting at byte	32	32	32
For a length of	16	16	16	For a length of	10	10	10
Starting value	50	10	0	Starting value	50	10	0
Increment by	6	15	0	Increment by	35	54	0

BYTE #	R	G	B	BYTE #	R	G	B
32	50	10	0	32	50	10	0
33	56	25	0	33	85	64	0
34	62	40	0	34	120	118	0
35	68	55	0	35	155	172	0
36	74	70	0	36	190	226	0
37	80	85	0	37	225	25	0
38	86	100	0	38	5	79	0
39	92	115	0	39	40	133	0
40	98	130	0	40	75	187	0
41	104	145	0	41	110	241	0
42	110	160	0	42	145	40	0
43	116	175	0	43	180	94	0
44	120	190	0	44	215	148	0
45	126	205	0	45	250	202	0
46	132	220	0	46	30	1	0
47	138	235	0	47	65	55	0
48	144	250	0	48	100	109	0

You can divide the color lookup tables or structure them in different ways, and they can contain various values representing a variety of colors (see photo 3a). You can store them in data libraries to be called by the main program during execution, or you can create them on the fly. The coloring program chooses a specific color for a specific object or group of objects from the color lookup tables. And you can simulate a variety of color and lighting effects by assigning specific ranges of colors to specific intensity or brightness levels (see table 1).

TEXTURE

You can create two general types of textures, visual and spatial, on computer-generated three-dimensional objects. A visual texture is a two-dimensional image of a texture created without affecting the geometric surface of the object; it only simulates a three-dimensional texture. A spatial texture, on the other hand, exists in three-dimensional space and affects the spatial integrity of an object's surface. Spatial textures are closer to the concept of real textures than visual textures are.

By *mapping* a digitized two-dimensional image onto the surface of a three-dimensional object you can create visual textures. This method, pioneered by Ed Catmull (see reference 3), affects the intensity and chromatic values of a surface but does not affect its smoothness. An alternate method for creating visual textures, developed by James Blinn and modified by several others (see references 1 and 7), simulates the imperfections on a smooth surface, not by affecting the surface itself but by altering the surface normals of the object. This alteration before shading causes the light to reflect in several directions, the way light would reflect if the object were actually textured.

Modeling a detailed mesh of planar polygons creates spatial textures. This approach, however, is time-consuming and extremely impractical. A more effective way uses a class of irregular shapes known as *fractals* (see references 5 and 11 and the article, "Fractals," on page 157). This method of creating textures on a smooth surface works by dividing recursively the polygons that make up an object into a variety of smaller irregular shapes, like those

(continued)

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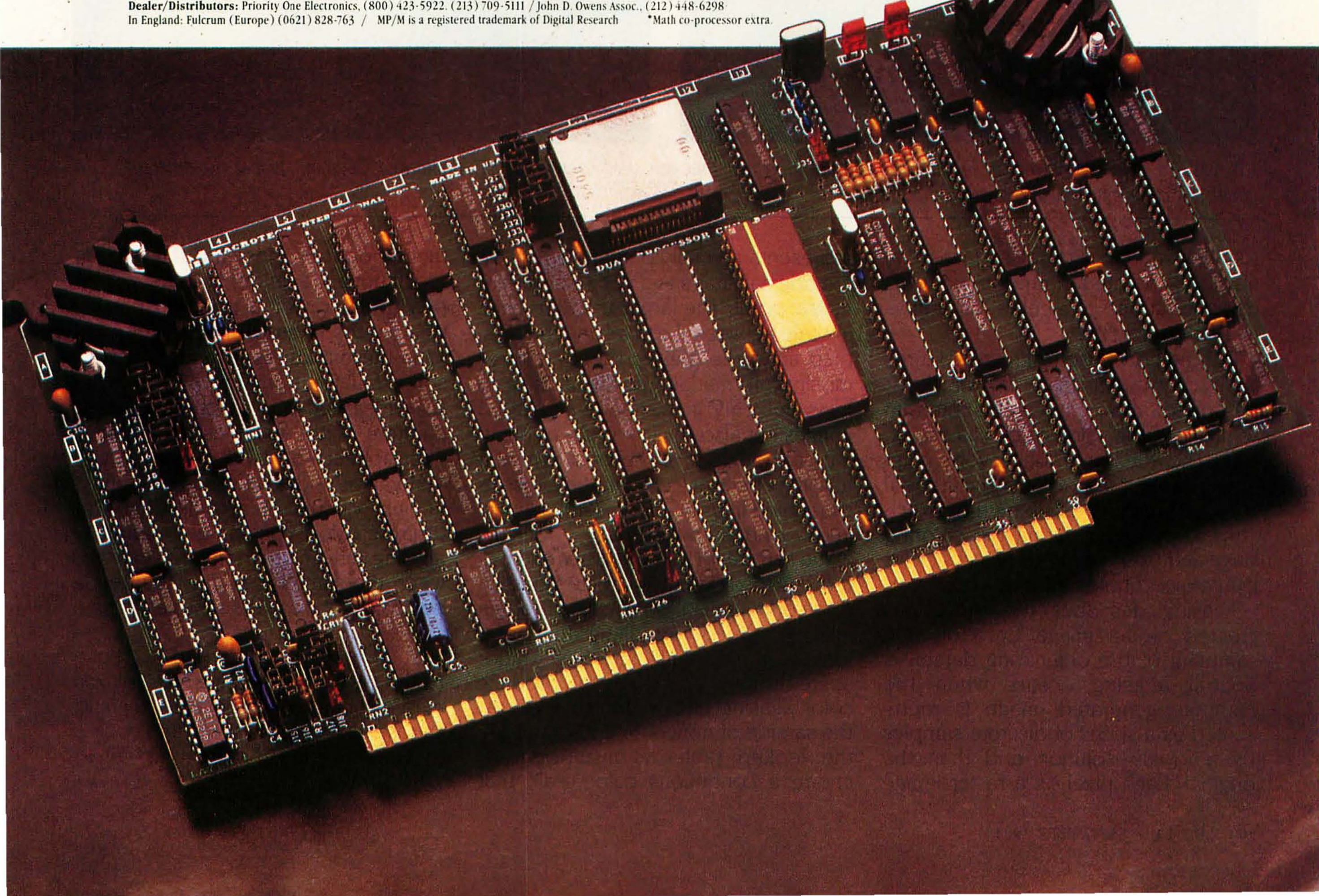
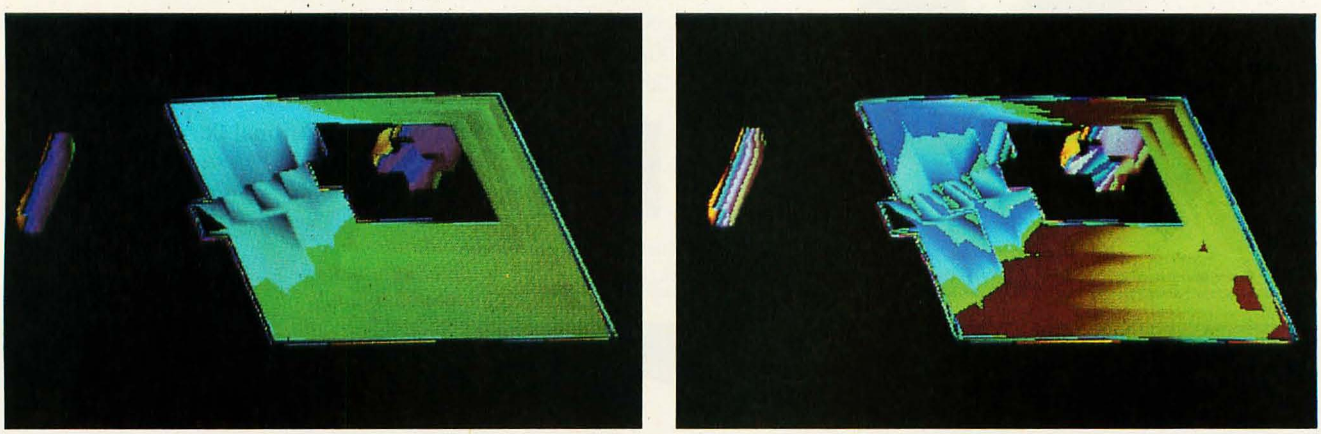


Photo 3a: *"Pattern 1.1" is rendered as an uncapped three-dimensional contour with hidden surfaces removed and color created by color lookup tables.*

Photo 3b: *"Pattern 1.4," a textured variation with color aliasing effects. The object is made of 254 polygons.*



Photos 4a and 4b: *Two steps of the color aliasing procedure that was used to generate "Pyramid and Column." Notice the different visual textures created by the coloring process.*

found in nature. Fractal surfaces can also be generated in random patterns or as iterations of algebraic formulas (see reference 13).

The method I use to create textures is much simpler than any of those described above. It creates random visual textures using color aliasing effects. These textures don't involve mapping nor do they perturb the normal polygon vectors describing the object. They are created during the coloring stage and exist only in an object's raster image (see photos 4a and 4b).

Aliasing describes the distortions created on an image by a discrete sampling of the originating database. Spatial aliasing occurs when the computer-generated image is represented as a series of discrete samples on a lower-resolution grid than the original. Each pixel on a raster image represents a small continuous area of the original image and not a single geometric point. The larger the difference in scale between the pixel and the sampled area, the greater the amount of missing information. You find aliasing effects not only in computer-generated images but also in such media as painting or photography. The most common aliasing effects in computer images are the jagged lines that represent diagonal lines or edges of objects.

You can create visual textures and patterns with different characteristics on three-dimensional objects with certain aliasing effects. By filling the color lookup tables with intensity values some distance apart, you can produce color aliasing effects. In other words, the sample of noncontinuous values in the lookup tables is insufficient to create a continuous color scale that blends optically. Instead of getting a continuous gradation, you get a stepped gradation or a textured pattern (see photos 1b and 3b). The use of color in these textures resembles that of some fauvist (from the French word *fauve*, meaning "wild") and expressionist painters of the twenties and thirties. They applied color with intense saturation values and represented the effect of light on the objects as blocks of discrete color. You can get additional aliasing effects with moiré patterns when the sampling grid encounters a periodic texture in the sampled image.

CREATING AN ORIGINAL

At the end of the creative process, you must display your final image—you must choose its final form. Three approaches to the production of static computer-art

(continued)

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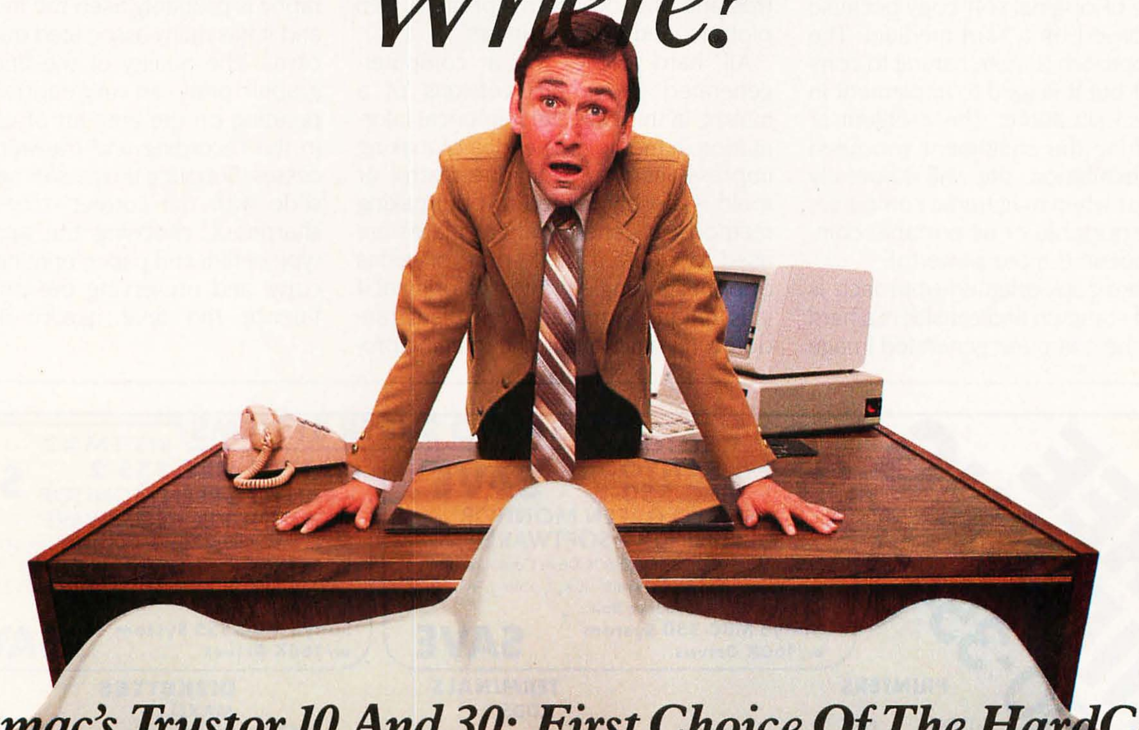

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originals dominate the scene: purist, hard-copy-oriented, and hybrid.

The purist approach contends that the original exists only in the computer environment—you must create it each time you view it. The numerical description of the image, the magnetic tape, and the image on the screen are considered originals.

A computer can create a fresh original on the spot if it has the appropriate hardware and software. You could call this type of original soft copy because it's not based on a hard medium. The purist approach is more natural to computer art but it is hard to implement in many real situations. The problem of transporting the equipment you need to the exhibition site will hopefully disappear when mainframe computers become portable or as portable computers become more powerful.

The hard-copy-oriented approach is the most common and considers a hard copy of the computer-generated image to be an original. The computer is only a creative and developmental tool and not the final support for the image. This approach favors the creation of a direct hard copy—ideally via a computer-controlled method with minimal manual intervention. Obviously, you want to transport the image to hard copy as accurately as possible. Several choices are available for your output, such as plain paper, photographic paper, and canvas, and also for the device, including electrostatic and dot-matrix printers, pen plotters, and ink-jet printers.

All hard copies of a computer-generated image are versions of a matrix, in this case the numerical information in memory. The idea of making impressions from a unique matrix or mold is closely related to printmaking methods in general, where plates are used to create a single print or series of prints. A single print is an original if it is unique. You can even plant randomizing functions in the imaging procedures to guarantee the uniqueness of each piece. Multiple prints are original if presented as a limited edition, where the artist decides to make several numbered copies and agrees not to make further copies from the same matrix. Unnumbered multiple copies are the least desirable type of print because the process of quality control and authenticity becomes difficult.

Of all the techniques for creating hard copies of computer images, photography is probably used the most often, and it has many associated quality concerns. The quality of the final photographic print can vary enormously depending on the amount of care taken in the recording and transferring processes. Shooting the master negative or slide with the correct exposure and sharpness, choosing the appropriate type of film and paper, printing the final copy, and preserving the print all influence the final quality. I usually

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photograph my work on slide film that offers high image definition, has good color balance, and is stable. I make my final prints on 20- by 24-inch glossy paper. Glossy paper seems to resemble the quality of the monitor image.

The results you can achieve with color printer technology vary. Pen plotters are limited to making line-based images, but they offer advantages such as the ability to choose from a wide variety of papers and colored inks. Some recent developments in electrostatic printing technology allow you to use large paper with good image resolution. The images produced by ink-jet color printers are especially interesting because the colored inks blend on the paper. Ink-jet methods that deposit the image on canvas have been developed by 3M Company (Scanmural) and by Ron MacNeil at the Visible Language Workshop at the Massachusetts Institute of Technology. These canvases take computer art hard copy away from a print-oriented medium and toward the more traditional concept of an original work of art.

The hybrid approach creates an original by combining computer technology with more traditional imaging techniques. The computer is the main tool in the creative process but not the only one.

Traditional printmaking techniques, such as silk screen, etching, and lithography, produce the final computer-generated images. The most common method for transferring the image to another medium is photography. Computer-controlled transferring methods are still rare. As more fine-arts users try to combine computer imaging with other imaging techniques, the hybrid approach is becoming much more common.

CONCLUSIONS

The computer is a contemporary tool and its use for the creation and manipulation of images opens possibilities in the field of artistic creation. It brings challenges and problems on all creative levels, aesthetic and technical, to artists, programmers, and engineers alike.

If you understand the limitations of computer-based imaging systems and take advantage of their capabilities, your imagination can explore untried creative paths. Today's computer art introduces new colors and new shapes—even a new sensibility that expands the nature of the aesthetic. ■

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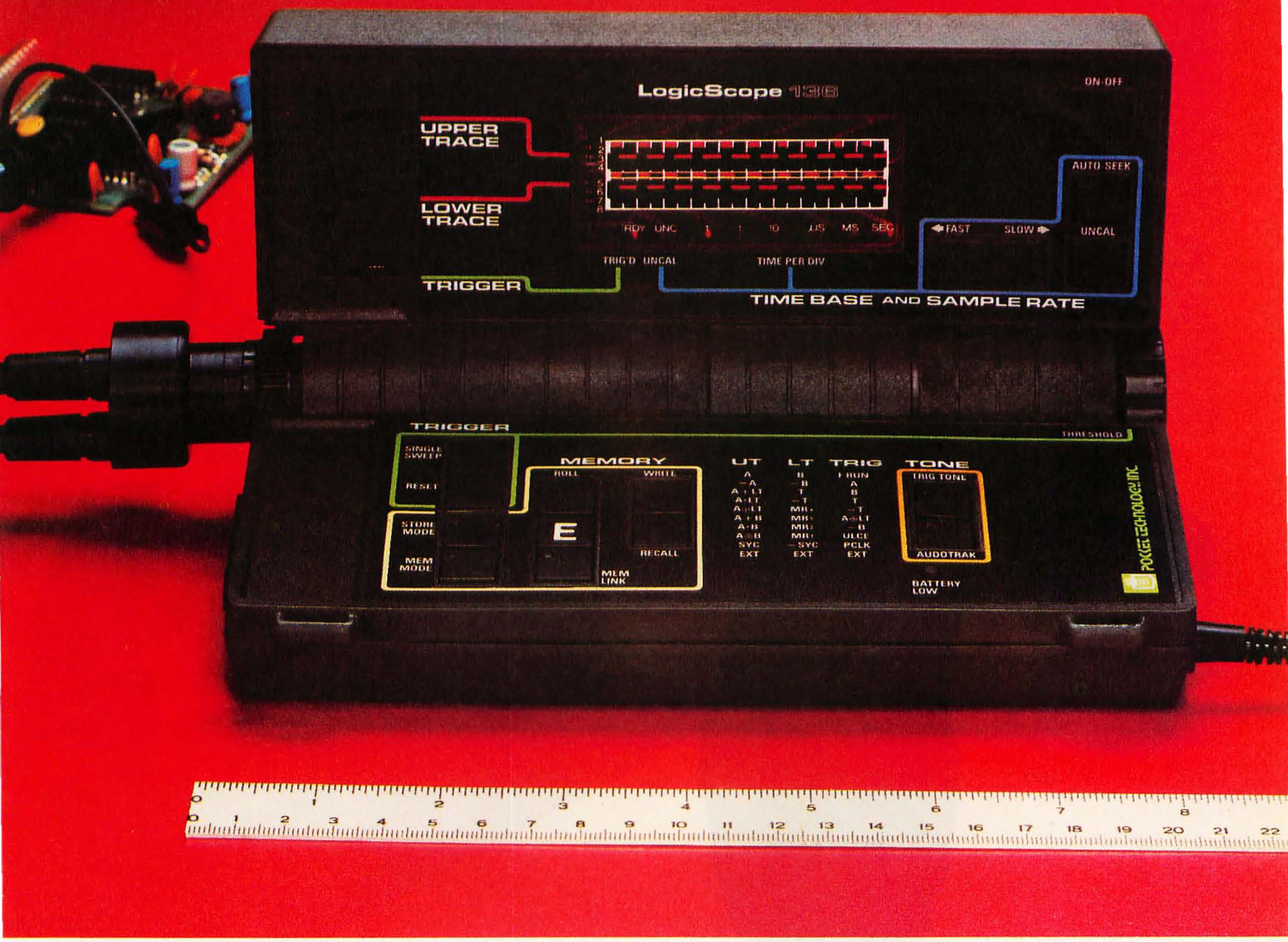

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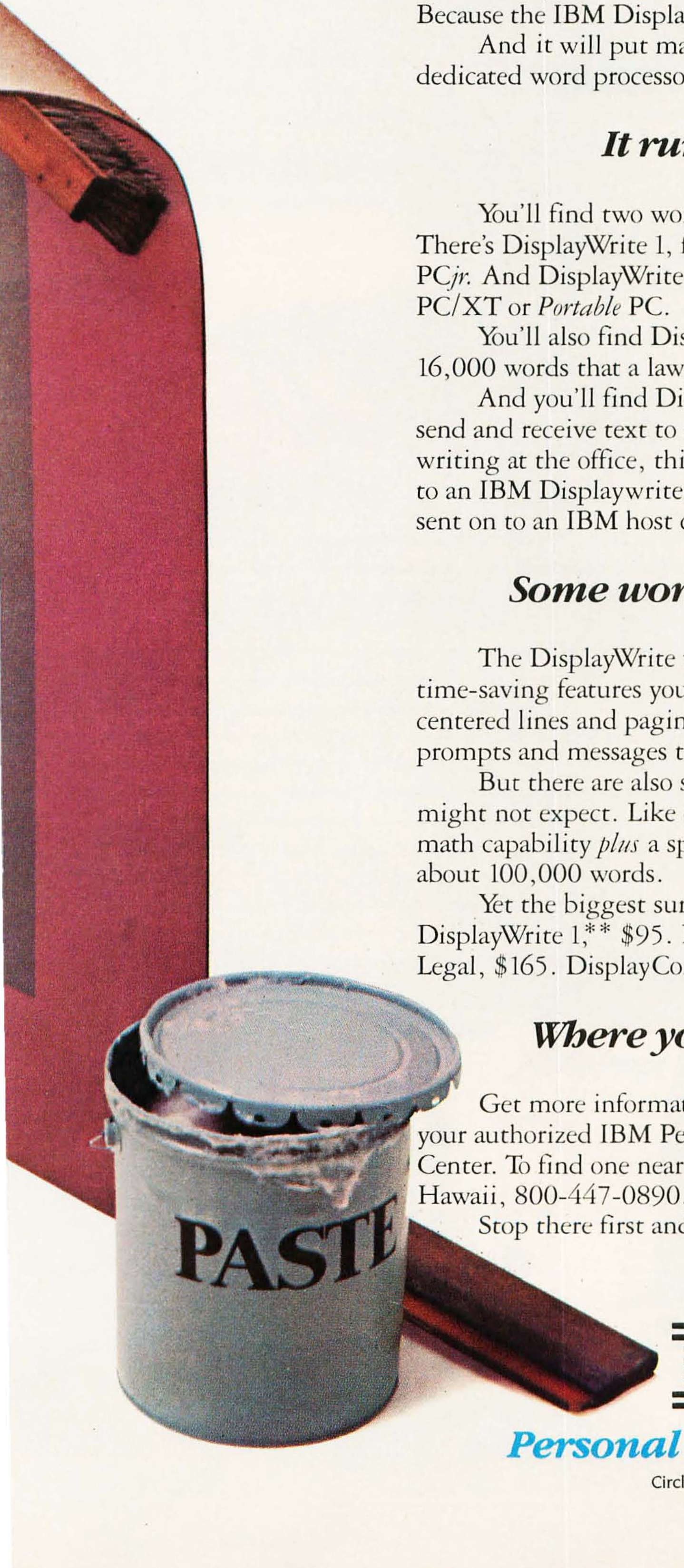

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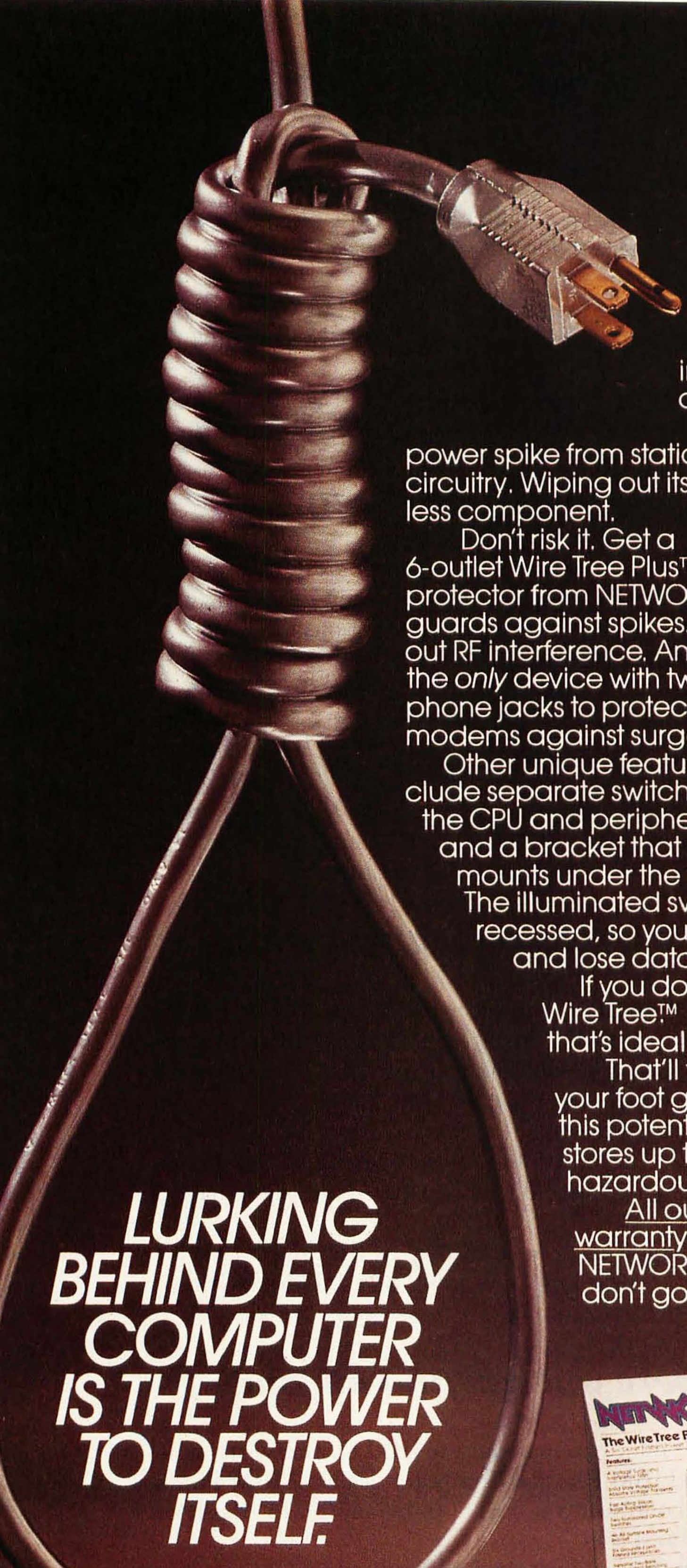
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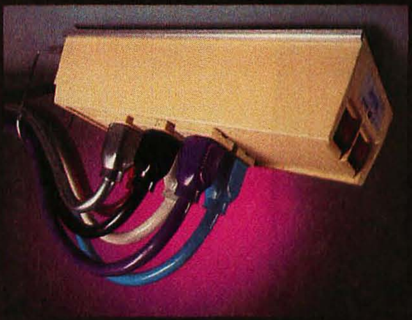

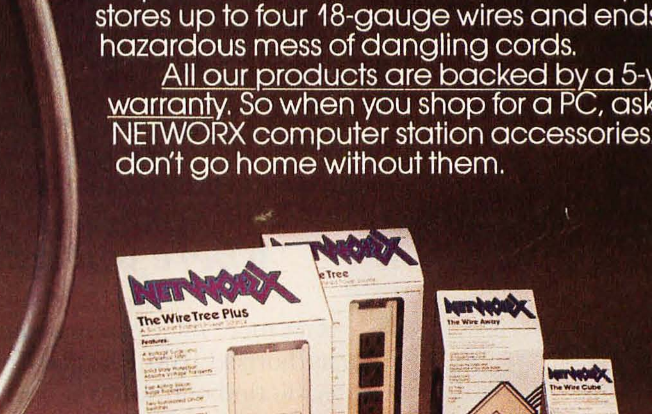
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COMPUTER LANDSCAPES

BY DANIEL COOPER

Computer graphics merge with silk-screen printing

COMPUTER ARTISTS share a common problem: once they have created an expressive composition, how do they turn it into a finished work of art? For most artists, it isn't enough to generate an interesting image that can only be seen on a computer screen. They want to make art that is physical, that has substance and immediacy, and that can respond to natural light.

A HAPPY MEDIUM

To turn computer-generated art into a physical reality, you could photograph the screen image to produce a color slide or transparency. With this method, the next step is producing an enlarged photographic print. The result, however, is more a representation of an artwork than an artwork in itself.

You could also use a color printer or plotter, but such devices, while fine for business graphics, might not meet your standards for artwork. And videotape is best suited to moving images, more in the realm of film than painting.

A more traditional option is serigraphy, the fine art of silk-screen printing. Serigraphy uses a stencil process that can mimic other forms, including computer imagery. In addition, it uses inks that mix like paint, and it is relatively inexpensive.

In this article I will discuss this artistic method, following the creative process from concept through computer programming to final printing of the serigraphs. I will also analyze one of my art programs to show the thinking and experimentation that went into it and to demonstrate how I ultimately realized the images in the traditional art medium.

You can create images on computers by using a paint system, a digital camera, or programming. Each method has its advantages, but I find programming particularly appropriate because of its relationship to mathematics and the relationship of mathematics to art. The calculating precision and speed of a personal computer let me use mathematics to create images in unexpected ways, bringing together the hard logic of math and the mysterious intuition of art.

DEVELOPING A PROGRAM

As an example, I present one of my programs called SineScape (listing 1). This program generates abstract landscape-like images by manipulating sine wave curves. The sine wave (figure 1a) is the archetypical wave form used in physics to describe the transmission of energy such as light, sound, or electricity. For me, it symbolizes cycles of nature and fundamental forces of the universe. Its shape is also reminiscent of the hills and valleys of landscape painting.

You might be surprised by the short length and relative simplicity of the SineScape program, which creates an image by repeating certain operations many times. Each time the program loops back to its beginning, it makes a small adjustment, assigning new quantities to the curve determinants. Thus, creating an image involves the artistic principle of theme and variation, building a picture with varieties of one basic form (figure 1b).

To achieve a sense of solidity, the SineScape program fills in each curve with vertical lines plotted from the central axis (figure 1c). This also provides a new visual element; by varying the spacing between lines, the program creates solid or striped forms, giving a more unique character to each set of curves.

The program suggests a sense of depth by overlapping one form on another and by moving the axis line up and down the screen. This produces a

(continued)

Daniel Cooper (1 Onyx Ave., Larkspur, CA 94939) *is a visual artist and has studied at Harvard University, The Boston Museum School, the Art Student's League (Woodstock, NY), and the University of California at Berkeley. He has worked with computers for five years and his works have appeared in numerous exhibitions on the East and West coasts.*

Listing 1: *The SineScape generator program in Applesoft* BASIC. *To run this program in color, substitute* 72 HCOLOR = INT(RND(1)*8) *and delete lines* 74 *and* 76.

```
10    REM ----------------------------------------------------------------
12    REM                          SINESCAPE
14    REM                       BY DANIEL COOPER
16    REM                           (C) 1984
18    REM ----------------------------------------------------------------
20    HGR2  :  HCOLOR= 7
22    REM --------------------DRAW BACKGROUND-----------------------------
24    FOR T = 0 TO 191 STEP 2: HPLOT 0, T TO 279,T: NEXT T
26    REM ----------------------------------------------------------------
28    REM                       CHOOSE VARIABLES
30    REM ----------------------------------------------------------------
32    REM -----------------------PHASE SHIFT------------------------------
34  A = INT (RND (1) * 200)
38    REM --------------------FREQUENCY FACTOR----------------------------
40  N = INT (RND (1) * 58) + 20
44    REM ----------------------AXIS LOCATION-----------------------------
46  Z = INT ( RND (1) * 92) + 50
50    REM ----------------------HEIGHT FACTOR-----------------------------
52  ZF = Z: IF Z > 96 THEN ZF = 96 - (Z - 96)
56    REM ----------------------CURVE  HEIGHT-----------------------------
58  W = INT ( RND (1) * ZF)
60    IF W < 10 THEN W = 10
64    REM ------------------------ STEPSIZE ------------------------------
66  G = INT ( RND (1) * 4) + 1
70    REM ------------------------- COLOR -------------------------------
72  C = INT ( RND (1) * 2)
74    HCOLOR = 7
76    IF C = 1 THEN HCOLOR = 0
80    REM ----------------------------------------------------------------
82    REM                       PLOTTING ROUTINE
84    REM ----------------------------------------------------------------
86    FOR X = 0 TO 279 STEP G
88    REM -----------------------COMPUTE   Y-----------------------------
90  Y = SIN ((X + A) / N) * W + Z
92    REM ------------------DRAW  VERTICAL  LINE--------------------------
94    HPLOT X,Z TO X,Y
96    NEXT X
98    REM -----------------------BEGIN AGAIN------------------------------
100    GOTO 34
```

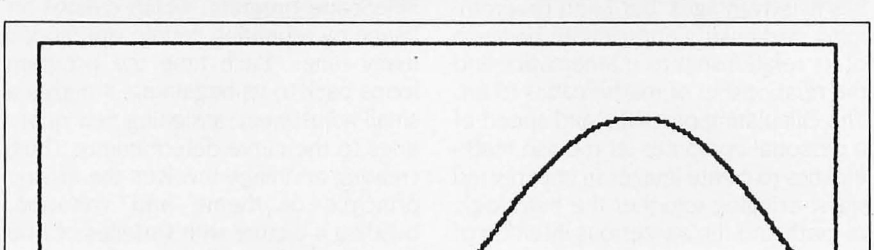

Figure 1a: A *computer-generated sine wave.*

richer, more complex image. Finally, SineScape selects a random quantity for each curve variable from among specific values allowed.

In operation, the program grows a landscape image. It does not dictate a specific composition or arrangement but rather a compositional procedure to be carried out by the computer.

You will note that SineScape has no endpoint; rather, it is an ongoing process. Because of the randomly chosen variables, you will get a different outcome each time it runs, and there is no telling exactly when an interesting configuration will occur out of the multiple overlappings. You have to watch, wait, and freeze the process at a moment when its form is most beautiful or right to you, then print it out (see example in figure 2).

Why not make the program interactive so that you could interface with the process at any time and either erase or add what you think is needed? Because to me the computer selection of random numbers for the variables in the curves is an important part of the artistic conception. This element lets happy accidents occur, things that you or I might not have consciously chosen because of habits in our usual ideas of balance or texture.

SERIGRAPHY

Once you have a computer image you are happy with, it's time for the next stage of the process: silk-screen printing, or serigraphy.

A silk screen consists of a rectangular wooden frame with a fine mesh fabric (previously silk, but now polyester) stretched tightly across it. When parts of the fabric are blocked out (in one of several ways), the open areas that are left will let ink pass through. A piece of paper is placed under the screen and ink is forced through the stencil by pulling a squeegee across it. This leaves a printed image on the paper, which is then removed and allowed to dry.

A technique called photo stenciling reproduces the computer image on the silk screen. First, a black-and-white dot-matrix copy of the design is printed out. The printout should have a good dense dot pattern, with each individual pixel (picture element) well defined.

The design on paper is enlarged and

(continued)

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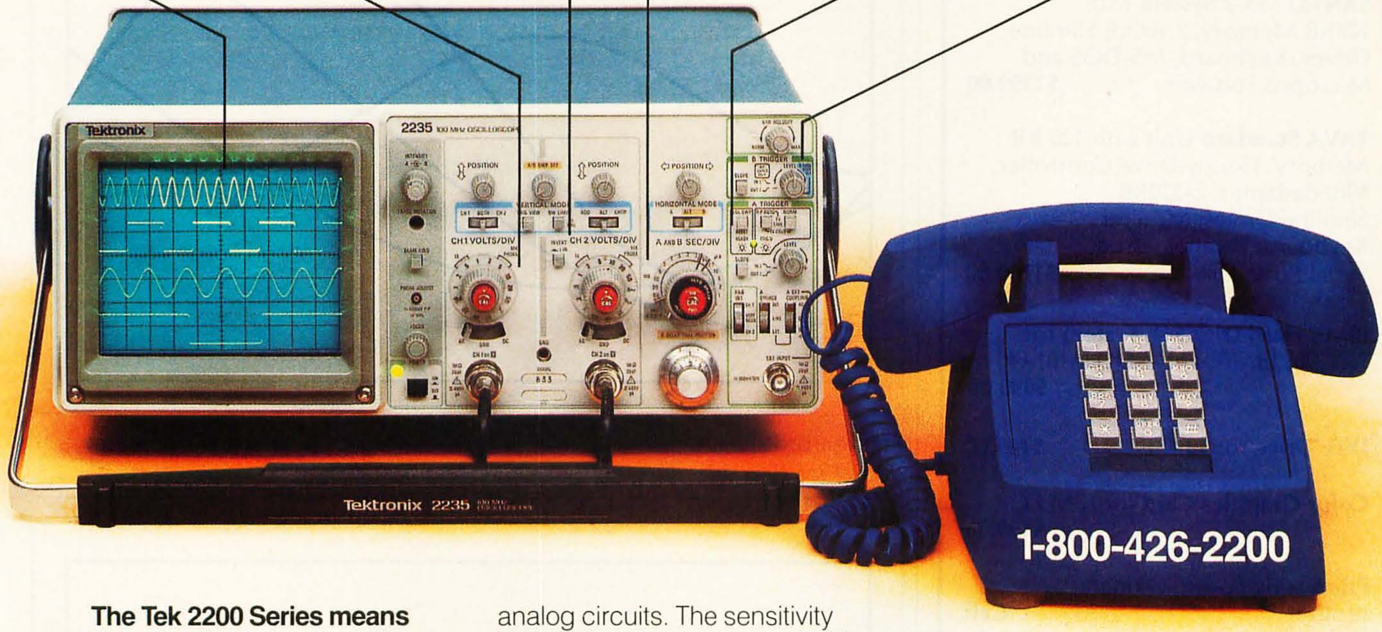

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transferred to a film positive, a thin sheet of clear plastic with the image in black on it (figure 3). A local blueprint company produces this for me on its process camera.

The lines and dots, when enlarged, are not hard edged but have slight bumps and irregularities as a result of the mechanical printing process. I find that these subtle deviations from precision add character to the image, a bit of organic imperfection that I find pleasing.

The silk screen is coated with a thin layer of light-sensitive emulsion, which

(continued)

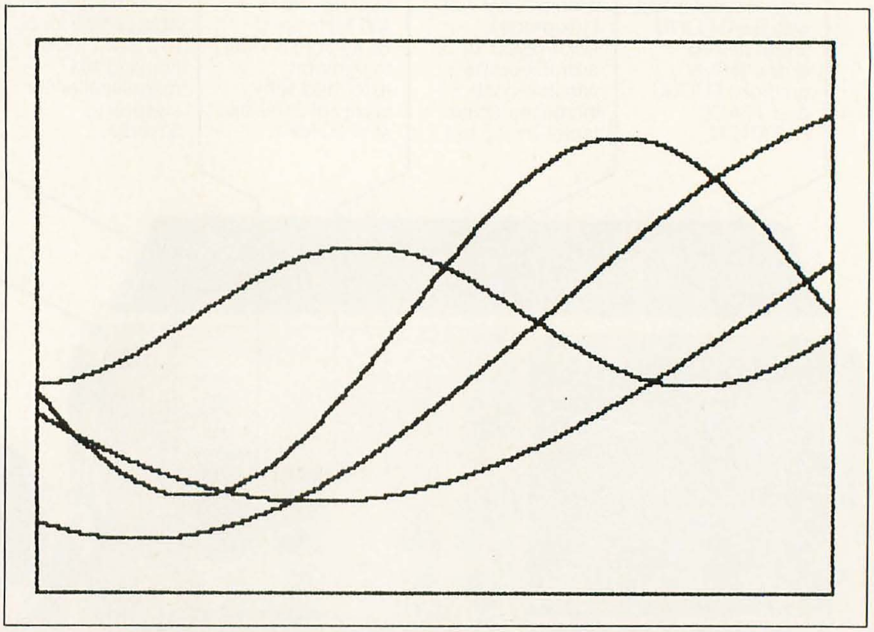

Figure 1b: *Repetition and variation of the sine wave begins the process of creating a work of computer art.*

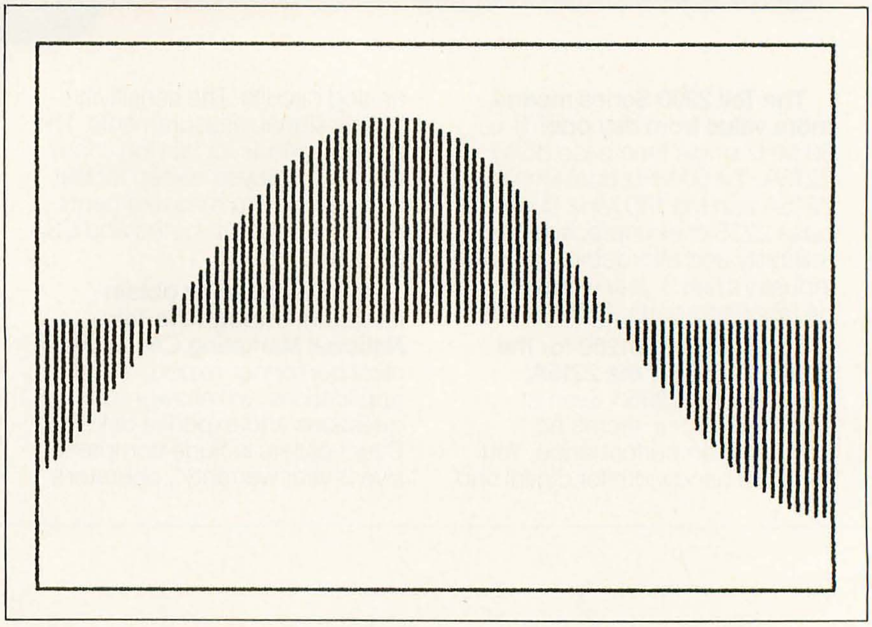

Figure 1c: *A sense of solidity is added to the sine wave by plotting lines from the x-axis to the curve.*

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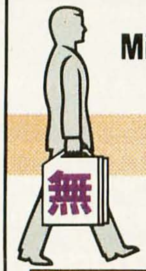

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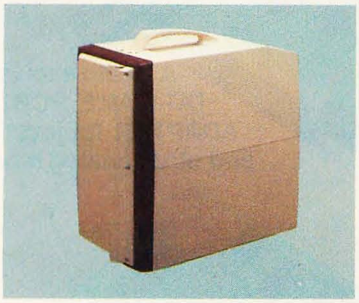

MUGEN

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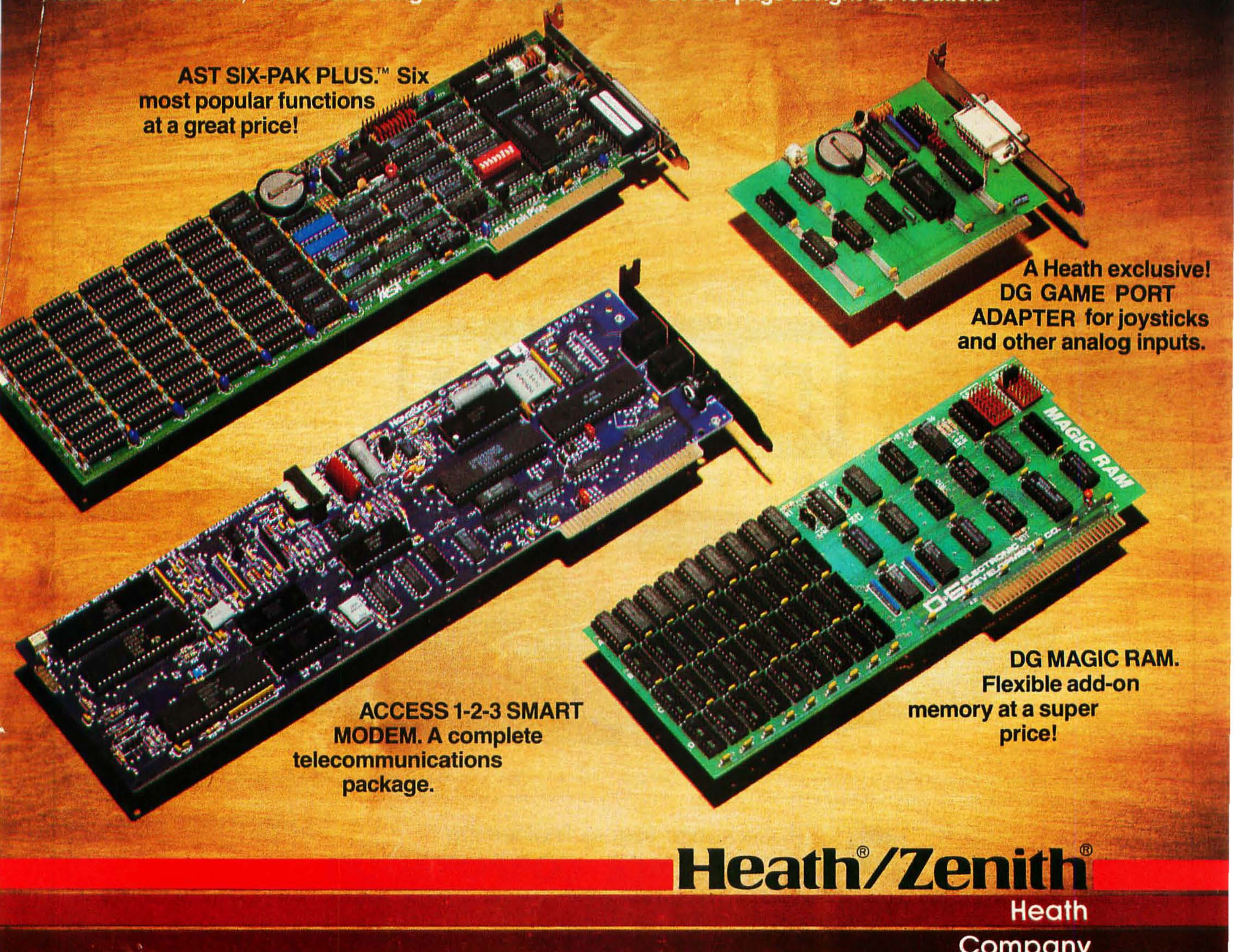

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has the consistency of white glue. The emulsion is allowed to dry on the screen in a dark room until it is ready for exposure.

To "burn" the screen, the film positive is placed on top of it and set in direct sunlight for about 30 seconds. The parts exposed to the sun react photochemically to become rubbery and impermeable. The screen is then sprayed with water, and the parts covered by the black image on the film positive wash off, leaving open screen fabric. The computer image has been captured as a photostencil.

(continued)

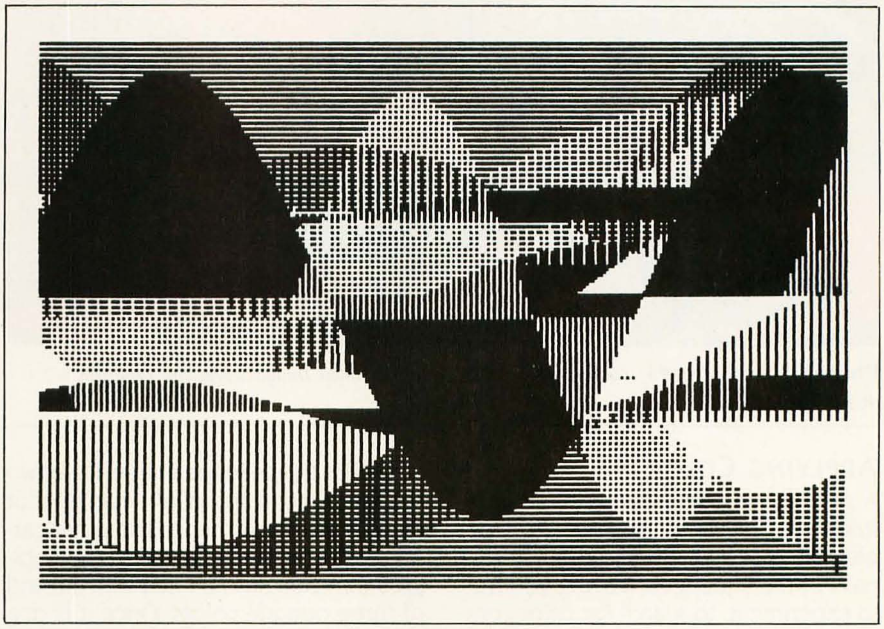

Figure 2: *A dot-matrix printout of a randomly generated "sinescape."*

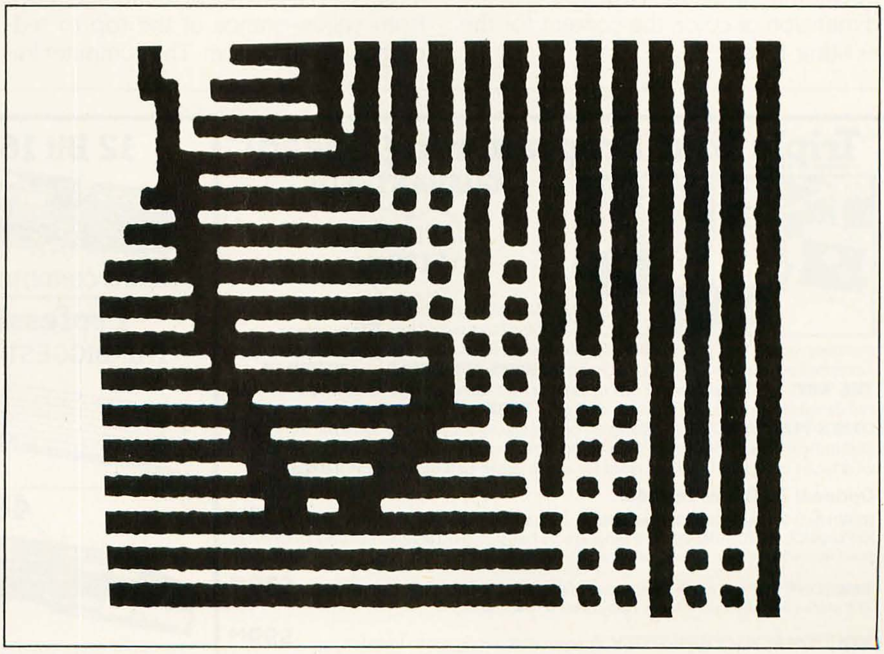

Figure 3: *The film positive used to create the silk screen retains the irregularities of the dot-matrix printout from which it was enlarged.*

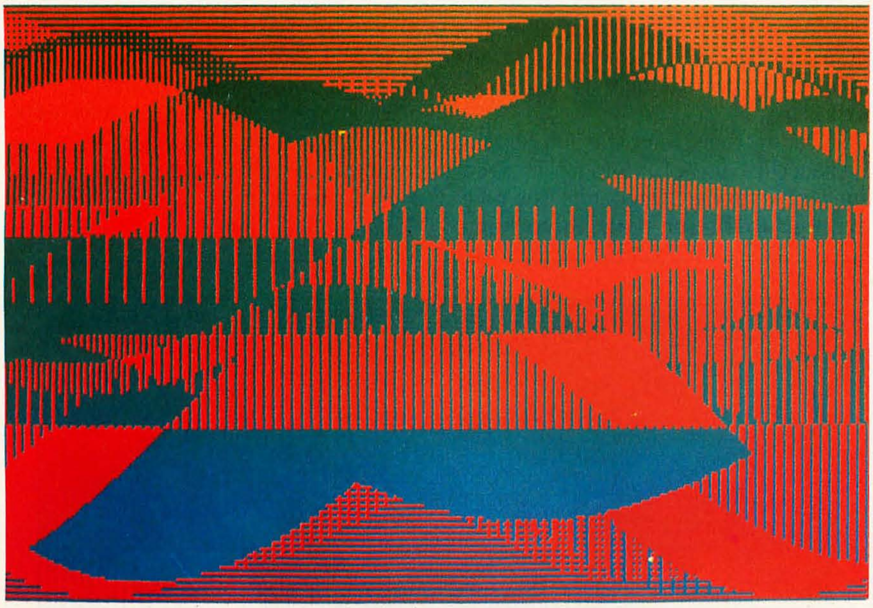

Photo 1: *SineScape #4, by Daniel Cooper, a silk-screened image using the program in listing 1.*

> *You feel a sense of accomplishment when you pull a successful print from beneath the screen.*

APPLYING COLOR

A new phase begins when color is introduced. The silk-screen process allows blending of two or more colors in one pass of the squeegee, leaving you free to experiment, to search for color combinations that inspire you. With the computer, you have produced a composition or structure. Now you add the dimension of color, the content for the existing form.

To print a SineScape image, I use two screens. One is an open rectangle that creates the background. The other carries the computer image. First the background rectangle is printed with a blend of three opaque colors. Once it is dry, the foreground goes on, using another three colors. For example, SineScape # 4 (photo 1) has a background that fades from yellow-orange at the top to red-orange at the bottom. The computer image fades from yellow-green to blue-green.

During the actual silk-screening, technical problems abound. Small imperfections, acceptable in the proof stage, must be corrected. Ink drying on the screen, bugs landing in the ink, dirt on your hands, streaks in the blends, and myriad other quirks in the process make it frustrating. Clean-up involves using toxic solvents, and heavy gloves and a gas mask are required.

But the result is worth it. You feel a thrilling sense of accomplishment when you pull a successful print from beneath the screen.

The computer is a magnificent tool, but it does not create art on its own. This takes the work and sensitivity of dedicated artists. I see possibilities for striking out in new directions, creating art that could not have been imagined before and evolving beyond novelty into meaningful expression. ■

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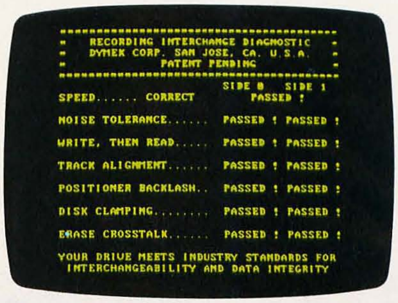

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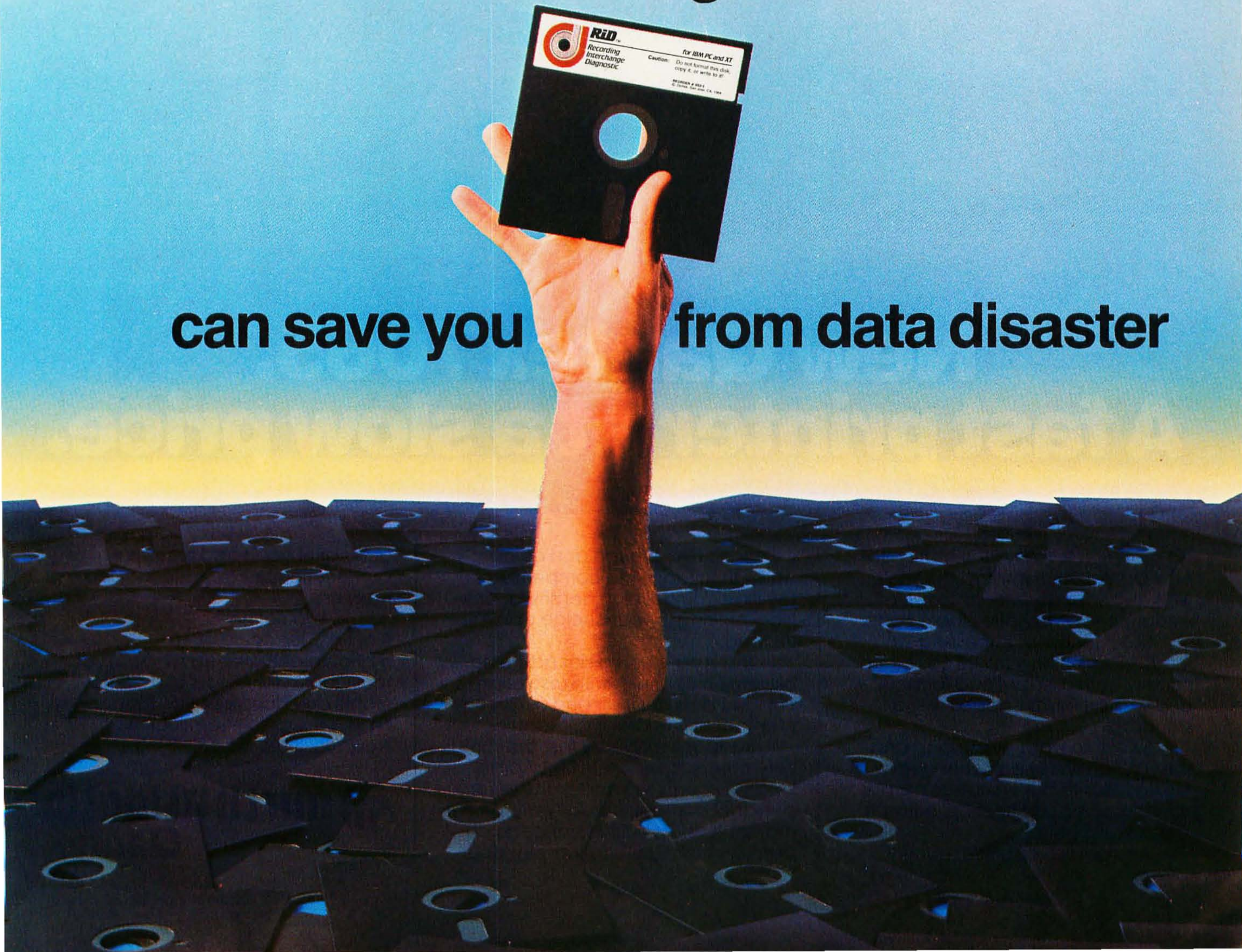

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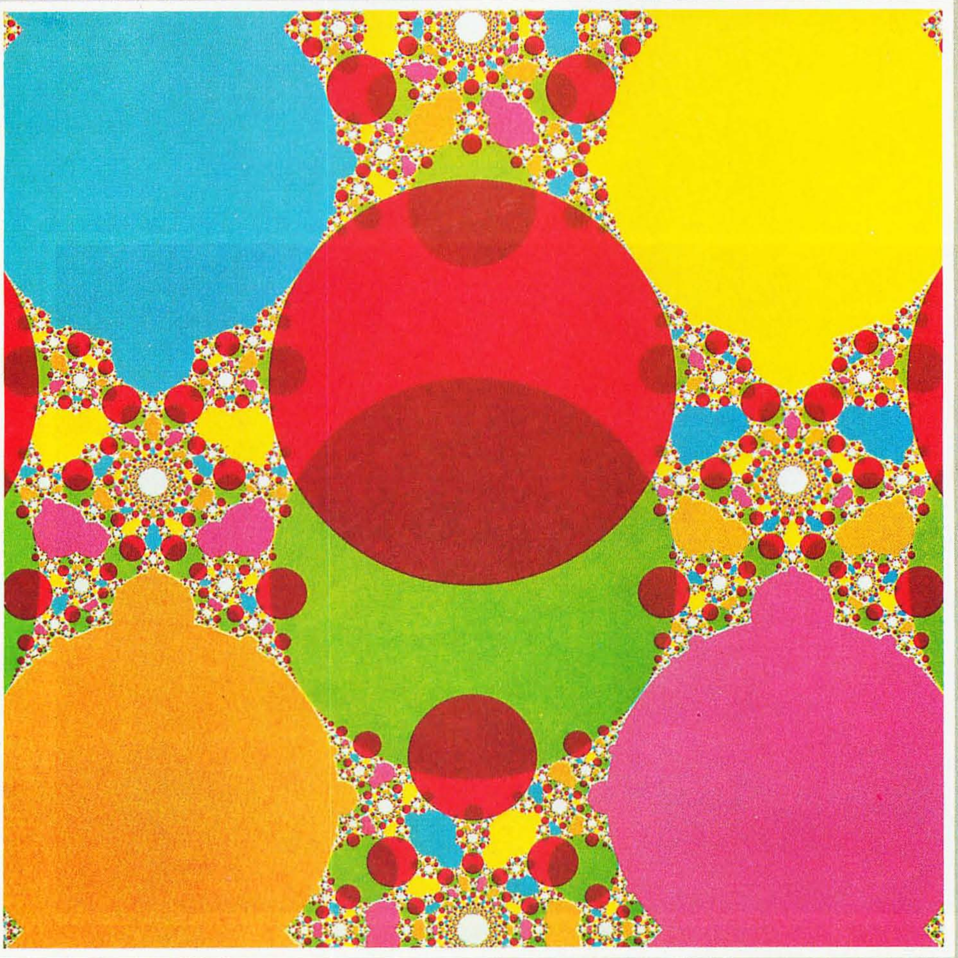
EDITOR'S CHOICE

BY JANE MORRILL TAZELAAR

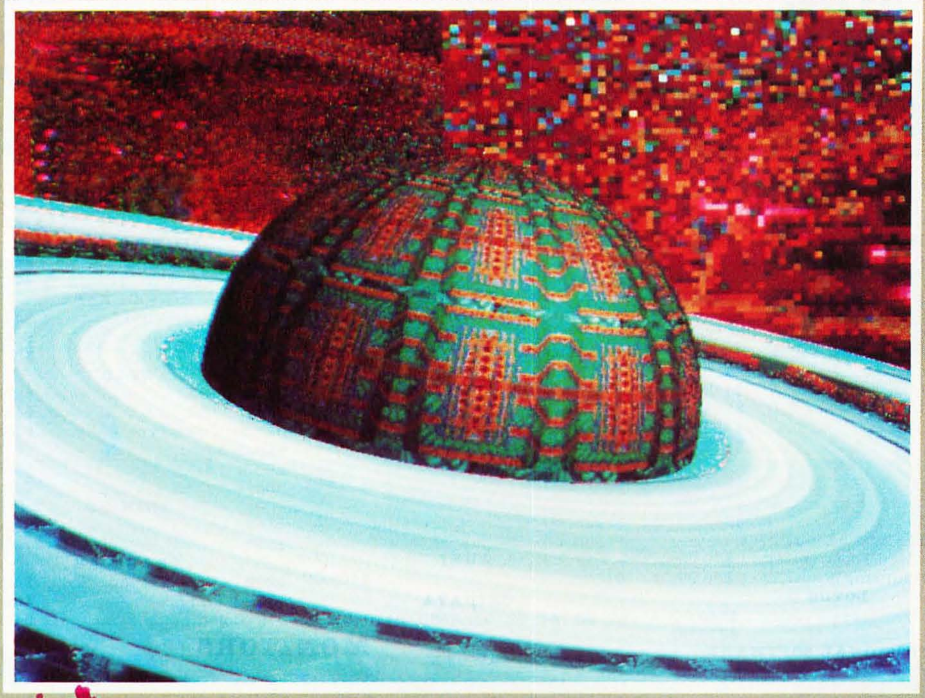
A small selection of computer-generated art. Enjoy!



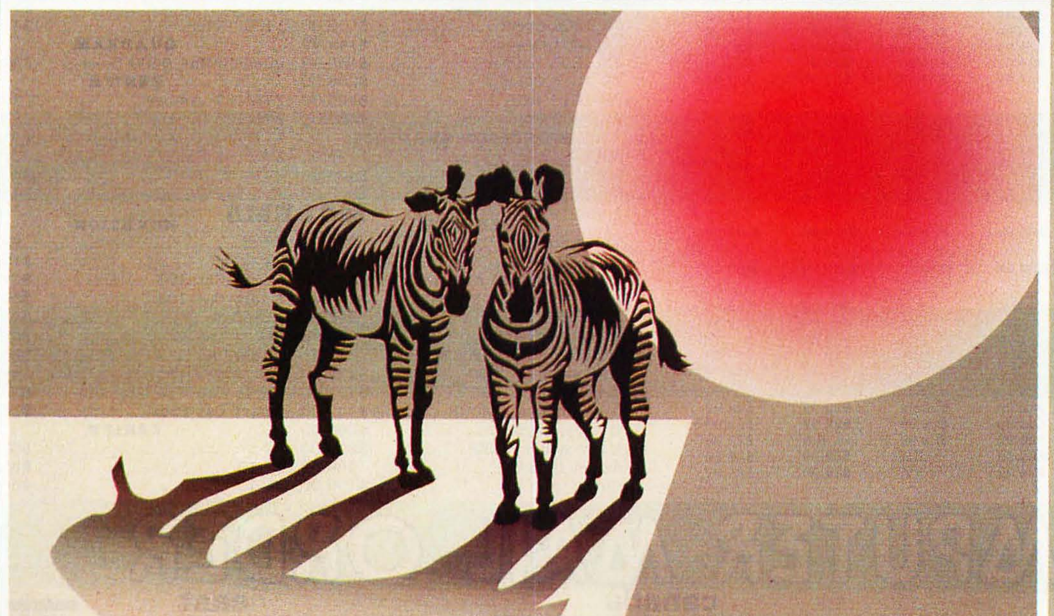
Self-Inverse Fractal Patchwork from "The Fractal Geometry of Nature" by Benoit B. Mandelbrot (IBM, Thomas J. Watson Research Center, POB 218, Yorktown Heights, NY 10598), published by W. H. Freeman and Co. Fractal geometry was discovered by Dr. Mandelbrot. Copyright © 1982 by Benoit B. Mandelbrot. Reproduced by permission.

This unenhanced original is from The Proud American Series by Joni Carter (11684 Ventura Blvd., #133, Studio City, CA 91604). She created such computer-generated paintings of the winners of various events at the Los Angeles Olympics. Copyright © 1984 by Joni Carter.

Ed's First String Art by Mike Newman (DICOMED Corp., 9700 Newton Ave. S., Minneapolis, MN 55431). He created two independent and differently colored line shapes and then allowed the computer to generate the rest of the lines through a process called in-betweening. Copyright © 1984 by Mike Newman.



Dr. Jim #1 by David Em (183 South Detroit St., Los Angeles, CA 90036). The painted sculpture effects that he achieves with the computer are the result of his particular mapping technique. Copyright © 1983 by David Em.



Z Plane by Ann Cook (DICOMED Corp., 9700 Newton Ave. S., Minneapolis, MN 55431). She created the shading around the sun with the in-betweening process using two circles of different colors and allowing the computer to generate the subtle circles of varying shades between them. The beautiful resolution seen here and in Ed's First String Art is the result of a direct digital-information-to-film process accomplished by DICOMED's D-148SR film recorder. Copyright © 1984 by Ann Cook.

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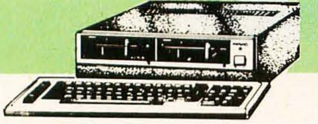

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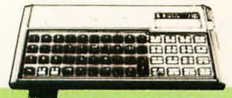

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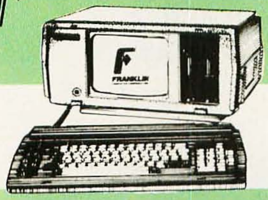

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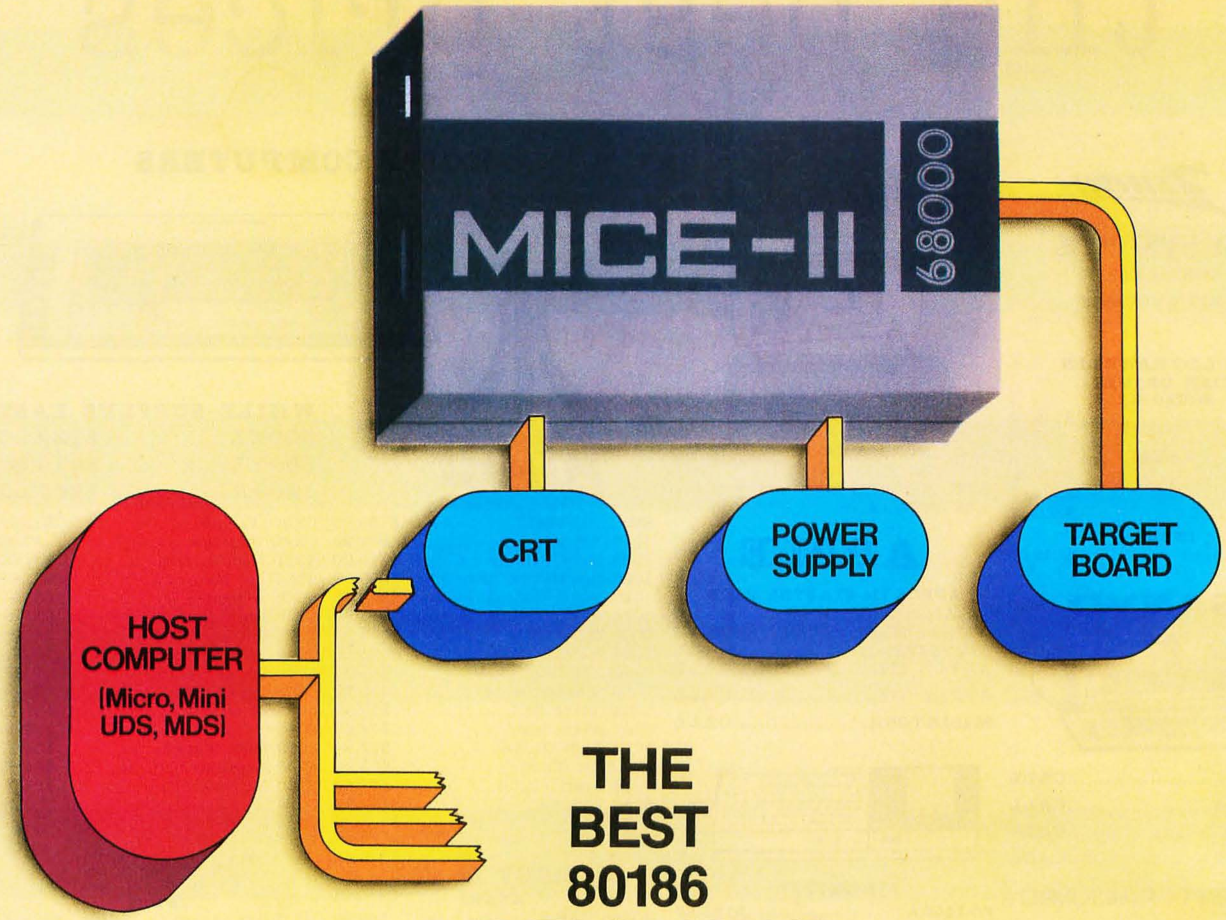

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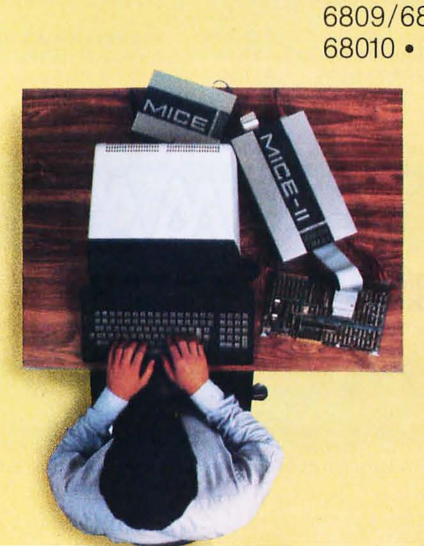

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GRAPHICS

COLOR CONSIDERATIONS

BY LEE BALDWIN

Understanding and choosing colors for computer graphics systems

MUCH HAS BEEN WRITTEN in computer-graphics literature about the representation of colors in display systems such as color monitors and various forms of plots, prints, video, and film recording. The chief concern has been the computer-science aspects of color manipulations, with very little said about the use of color as an emotive and persuasive psychological force. Likewise, little has been written about the best uses of color in systems of modest capability, e.g., a medium-resolution display capable of 64 or fewer colors.

In this article, I will discuss color models, harmonic colors, descriptive color systems, and the user interface, in the context of the computer "paint" system.

Each of these topics covers a different aspect of the viewer's perception of visual messages and is therefore relevant to a proper paint system design methodology. The development of basic ideas is directed at the clearer understanding by artists and computer scientists of one another's discipline.

Color is not well understood. Whether from the standpoint of psychological effect, electrochemical reaction of the visual system, the eye's ability to match colors, or the mapping of color agents to color effects, there is currently no comprehensive color theory. A desirable theory is one that would at least permit an explanation of the color phenomena in perceptual terms, distinctions between perceptual and descriptive models, and the matching of colors between media.

COLOR MODELS

A color model is a mathematical explanation of a color behavior context. Since color science is inexact, there are numerous models. Different models exist for input and mixing of colors, storage of color information, and output of colors to various media.

The range of natural colors that the eye perceives in nature is greater than the color range for photographic film dyes, which in turn is larger than the modern TV color gamut and the ranges for inks, dyes, and paint pigments. No artificial media approach the color acuity of human vision. Many of the existing compromises, such as TV, paint, and color photography, are nevertheless acceptable.

Since computer-generated pictures are first developed using color monitors and later translated into other forms, the color subsets of human vision that are relevant to a discussion of computer graphics are the ranges for television, film dyes, and print media. Conversion between color media is difficult and inexact, and although none of these color subsets approach reality, practical conversion between them is still desirable. As background, we will first discuss the basis for color monitor displays: the RGB (red-green-blue) *color space*.

Lee Baldwin (Suite 221, 119 West Pender St., Vancouver, BC V6B 1S5, Canada) is chief of software development for Vertigo Imagery Systems Inc. His hobbies include jazz piano, creative writing, and painting.

THE RGB COLOR SPACE

Human vision achieves color effects partly through the presence of three known visual pigments in the eye. These pigments interpret light centered at three different points, the standard observer's range (360- to 830-nanometer (nm) wavelength). Peak sensitivities of the visual pigments, located in the cones of the retina, are located at 630 nm (red), 530 nm (green), and 450 nm (blue).

It is not the mixture of intensities taken at these three wavelengths but a comparison of intensities that determines our perception of color. This comparison is made via a field arithmetic performed by the retina and the cortex. The presence of three independent sensing modes leads to the representation of color ranges as three-

(continued)

dimensional color spaces (see figure 2). This *tristimulus* theory of vision thus provides an imperative to construct color-reproduction methods involving three primary or basic colors.

Generally, any group of two or more colors will generate a color space. The only magic involved in the selection of primaries to form a useful color space is that three is the optimal number; the *hues* of the primaries (what most people think of as colors) are chosen to create the greatest range in their mixtures.

We refer to the color space defined by red, green, and blue phosphors on a monitor display as RGB, or the RGB color space. Color monitors use three separately controlled (and colorless) electron guns, each exciting one of the RGB phosphors, to achieve a mixture of colored light at the monitor's surface. These phosphors are chosen to produce the widest range of colors; in fact, the displayable colors for monitors span a greater range than those of color film or printer's inks. The modern broadcast TV gamut is, however, smaller than the range for film dyes, as shown in figure 1, which depicts the color spaces of television, film, and print media. The graph is based on the work of the International Commission on Illumination (CIE), which was begun in the late 1920s primarily to create a pigment-matching methodology so that the color range perceived by humans might be depicted and understood, as well as to define several standard white-light illuminants and three primary light colors that span the color space of the diagram in figure 1. RGB monitors are calibrated according to a standard daylight white light known as illuminant D65, whose wavelength is shown in figure 1.

Memory devices for computer graphics most often store digital color information in terms of red, green, and blue electron-gun intensity values for each physical point on the screen. Thus, much of the computation regarding color in computer graphics takes place in terms of intensities of RGB primaries.

The RGB mixing of colored light from a monitor is an *additive-primary* system, where red, green, and blue are primaries. The way light mixes is called *additive*: red light plus green light creates a yellow or orange light, while equal amounts of red, green, and blue produce light gray or white light. The behavior of this system is unfamiliar to most people. Mixing and specification of color in RGB is nonintuitive and difficult.

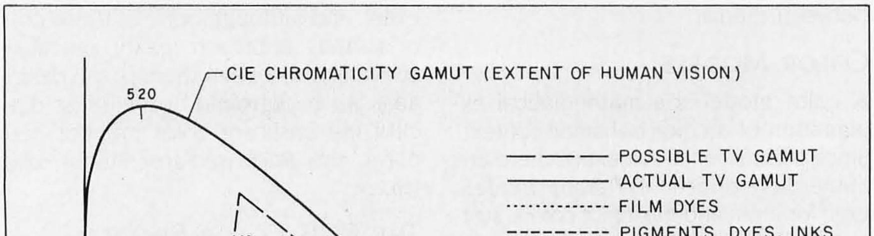

Figure 1: *A diagram indicating the color spaces, or "ranges," of human vision, television, photographic film, and print media.*

Color mixing for film dyes and print media follows the *secondary-subtractive* system, in which the secondary colors—cyan, magenta, and yellow—are mixed in a way that can be thought of as overlaying colored gels: magenta pigment mixed with yellow pigment produces orange, and the mix of all three is black. This system, termed *CMY* after its primaries, is familiar to painters, printers, and film processors.

It is not necessary or desirable for humans to think of color in terms of relative intensities of the RGB primaries, as it leads to awkward and nondescriptive color definitions. It is better to develop color models that can represent all of the colors available to an RGB display device while retaining descriptive factors already in common usage such as hue, color, intensity, brightness, lightness, saturation, tint, shade, tone, and value.

The following figures depict the RGB color space and its transformation into a more descriptive color space with which designers, architects, artists, and laymen will be familiar.

THE RGB COLOR CUBE

Intensities or voltages of the red, green, and blue electron guns of a color monitor are independently controlled, hence it becomes natural to think of the RGB system in terms of a three-dimensional space, a color space. The three color axes, representing intensity levels of the independent primaries, may be thought of as having values from zero to one, or from zero to 100 percent. Figure 2 illustrates the arrangement of the RGB primaries, the CMY secondaries, plus black and white, on the RGB color cube.

All of the colors possible from the additive mixing of colored light from a color monitor can be represented somewhere in this color cube. (It is not the case that the colors from a monitor fill this space completely; actual monitor colors form a subset of this space known as the color gamut.) It is easy to see that people will have trouble achiev-

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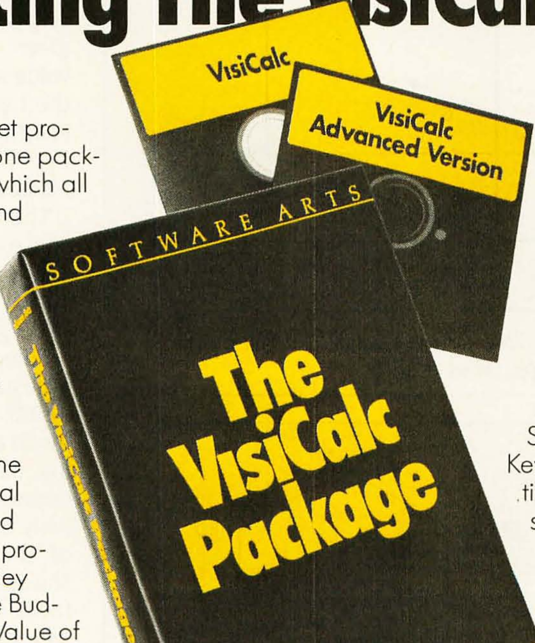

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ing a particular color mixture by specifying percentages of three additive primaries.

Intuitive color interfaces must display a sampling of the available hue range on the monitor. The operator first points to a hue and then adjusts the purity of the hue (its saturation, or tint) and its value, or shade. Such a model is descriptive, as it uses concepts that are already in the language in a systematic way. This description fits the hue, saturation, and value color model, proposed by A. R. Smith at the New York Institute of Technology in the 1970s in a technical paper entitled "Color Gamut Transform Pairs."

THE HSV COLOR MODEL

The hue, saturation, and value (HSV) color model is derived from the RGB model and has descriptive advantages over RGB for color mixing in computer graphics systems.

The advantage of descriptive color models can be suggested by two examples: pink is described as red light mixed with white light, and gold is described as desaturated (grayed) yellow. In the RGB color system, how does one mix white light with other colors if there is no explicit control for the amount of white light? How does one add gray to a color in RGB? How would one find the gray to add?

In the RGB color cube of figure 2, note the diagonal axis extending from black (r,g,b = 0,0,0) to white (r,g,b, = 1,1,1). If the color cube is viewed along this axis looking from white to black, the projected shape will appear as a hexagon with the principal colors (the primaries and secondaries) situated at its vertices (figure 3).

The above shape is also the bottom of the hexcone shown in figure 4. This solid is a deformation of the RGB color cube with more potential for taking human factors into account, that is, improving the user interface.

The HSV color model can represent all hues and colors possible to the RGB model. Hues are laid out around the edges of the hexcone, arbitrarily defined as starting from red at zero degrees, progressing counterclockwise toward yellow (hue angle = 60 degrees), green (120 degrees), cyan, and so on. The value (V) of a color is the distance along the vertical axis from black ($V = 0$) to white ($V = 1$ or 100 percent). Saturation (S), the purity of a color as compared to its maximum purity at a given value, is the distance from the value axis radially toward the surface of the hexcone. Colors on the value axis itself (where $S=0$) are shades of gray. Pure hues are found at the edges of the hexcone where $S=1$ and $V=1$.

The HSV system is descriptive in the sense that its axes are named for perceptual quantities. HSV offers more obvious ways to explain colors such as pink, gold, or light blue.

Selection of a pure hue, followed by adjustment of value and saturation, is intuitive. Tints and shades common to much artwork are produced by decreasing saturation (adding white) or decreasing value (adding black), respectively. Tints are located on the top plane of the hexcone with the pure hues; shades are found on the outside surfaces of the hexcone. Tones are everywhere within the hexcone's volume.

HSV is superior to RGB for at least the user interface of a system requiring color input/output (I/O). Thinking of HSV as a distortion of RGB space suggests conversion algorithms: linear transformations from RGB to HSV (and back) permit storage and display of pixel (picture element) values to be handled in

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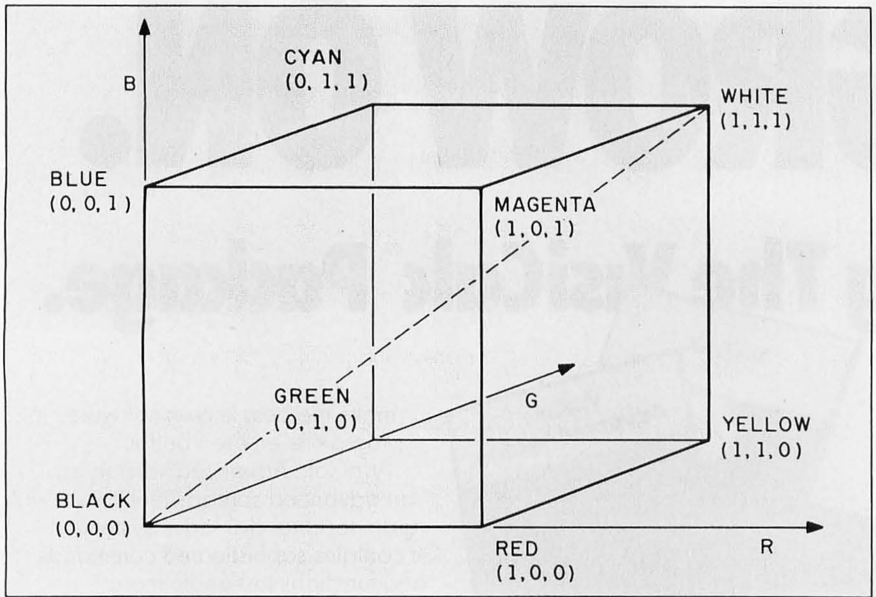

Figure 2: *The RGB color cube, a model that allows for visualization and mathematical representation of color relationships. Points are plotted as (r, g, b).*

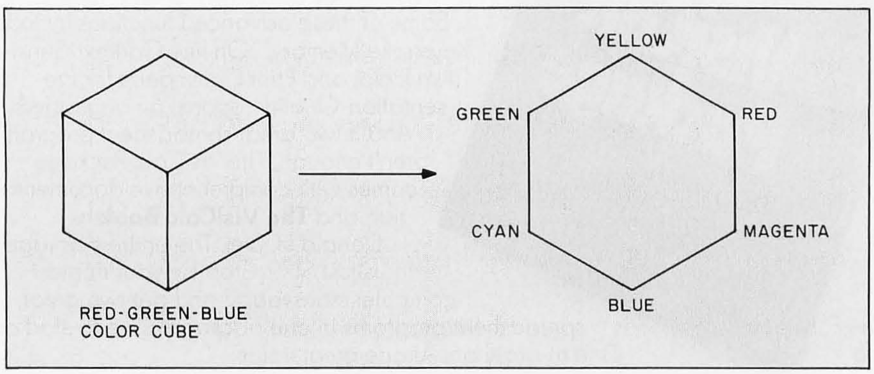

Figure 3: *The RGB color cube, when viewed along the diagonal black-white axis appears as a hexagon, with primary colors (red, green, and blue) and secondary colors (cyan, magenta, and yellow) situated at the vertices.*

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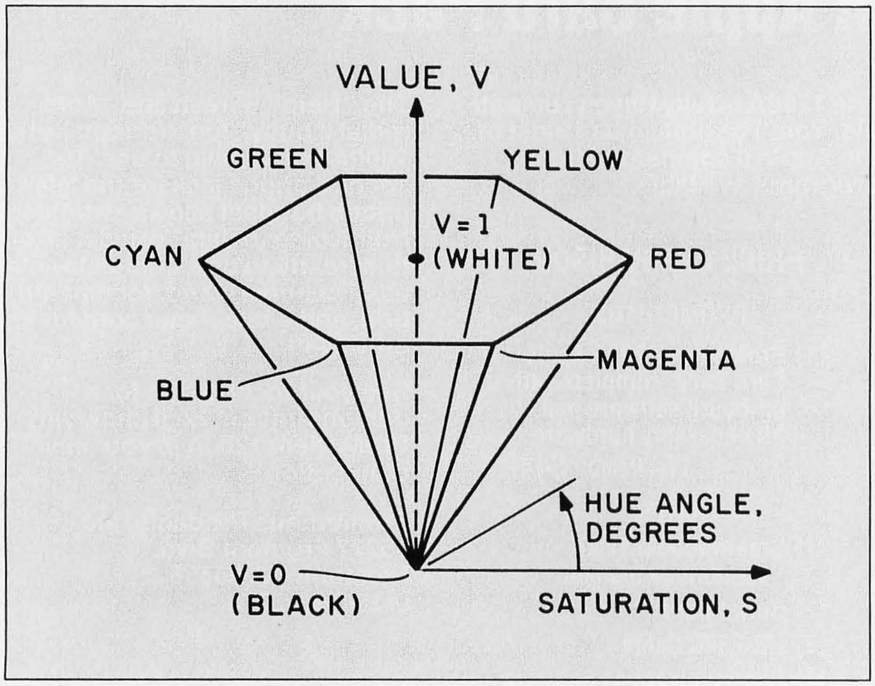

Figure 4: *A hexcone representing the hue, saturation, and value* (HSV) *color model.*

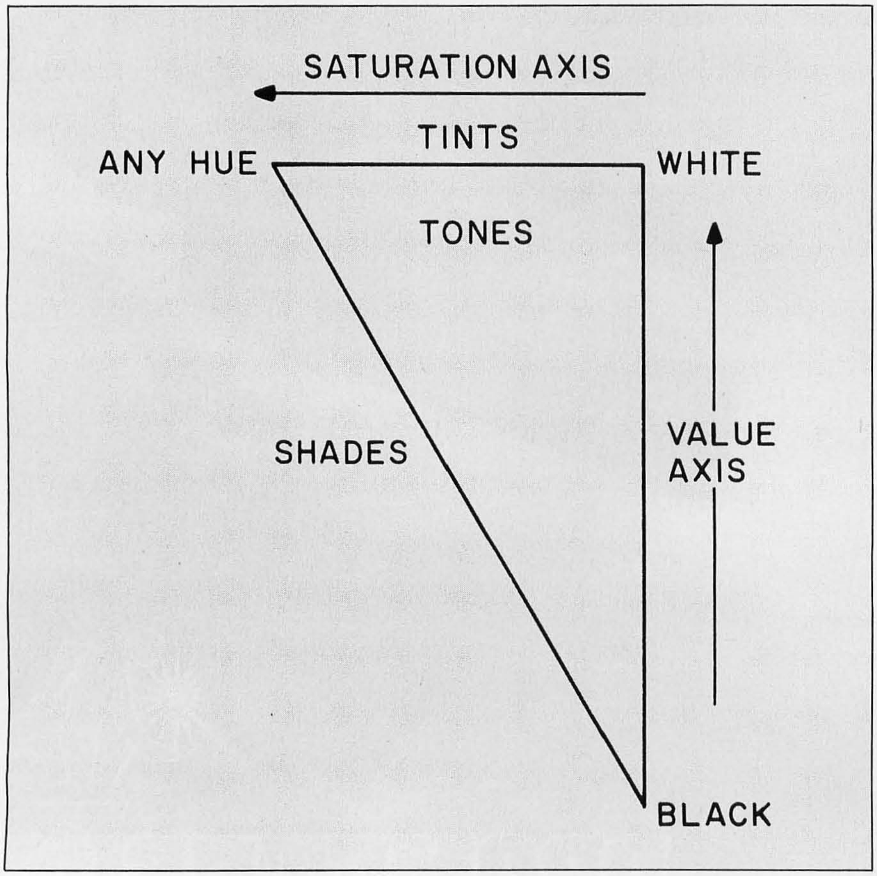

Figure 5: *Cross section of the* HSV *hexcone showing tint, shade, and tone.*

the RGB system, while input and computation may be done using HSV. Such transformation algorithms are discussed below.

An incorrect assumption in the use of RGB, HSV, and other color spaces is that they correspond to the complete range of human vision (see figure 1). There have been major efforts to measure and codify human color perception (e.g., the CIE), all of which have been done for *reflected light*, the light "given off" by ordinary objects when a light source shines on them). The emitted light of color monitors behaves differently from reflected light, and there is as yet no standard color range for monitors.

AN HSV INTERFACE

The implementation of HSV in a paint system user interface is straightforward. The object of any interface includes defining the most succinct input possible through a minimal set of operations, using the smallest number of input devices. We shall suggest a prototype interface such as seen in figure 6, using a color monitor, a keyboard, and a digitizing tablet and describe its operation for the selection and mixing of color (see figure 6).

The monitor operates in two modes, monochrome-alphanumeric display and color-picture display. To avoid repainting the picture each time a menu is accessed, separate memory segments for each mode must be provided. It must be possible to split the display screen under software control and to make selections from brief menus without obliterating the entire picture. This arrangement avoids the necessity of using an additional monitor screen as a command interface.

Also operating in two modes, the digitizing tablet offers a command input facility and a "paint" facility. In command mode, location of the screen cursor by moving the stylus allows pointing at menu options to select drawing operations. In paint mode, the tablet/stylus/screen tool allows creation, selection, and storage of "brushes" (cursor shapes) and pictures.

COLOR SELECTION USING HSV

The implementation of HSV requires that certain color manipulations be available in the "paintbox," as described

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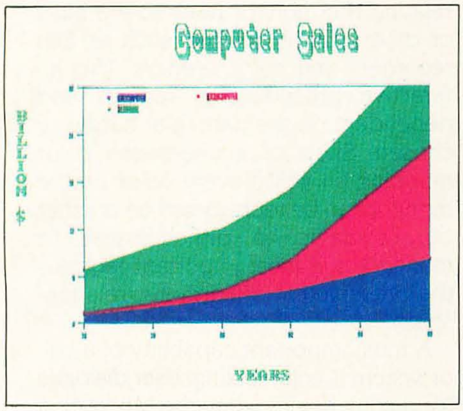

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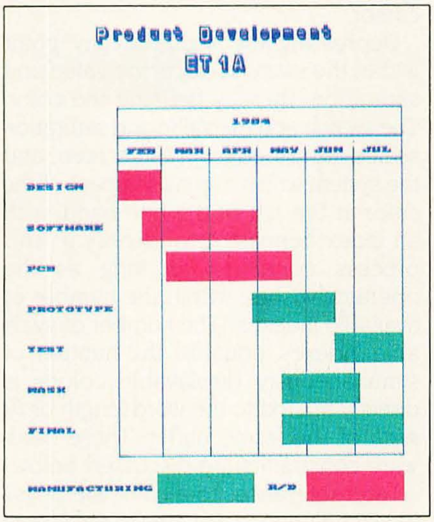

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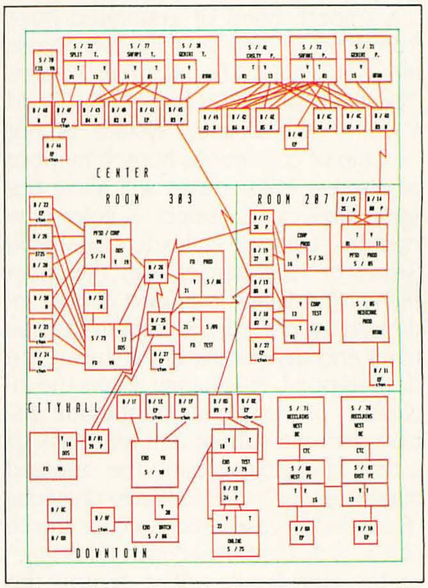

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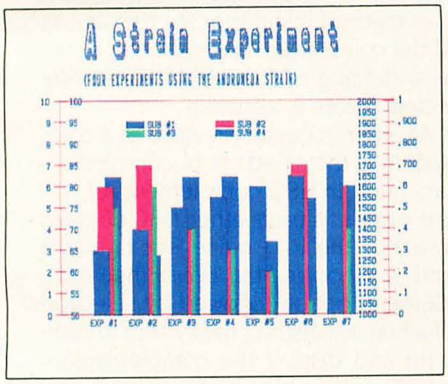

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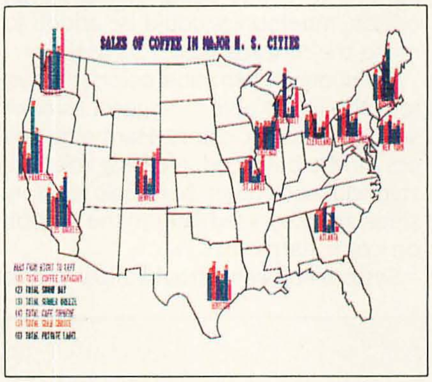

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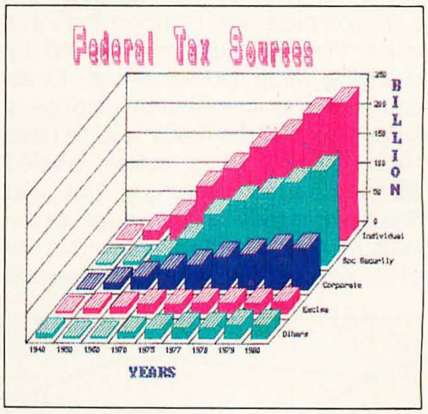

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in the paragraphs that follow.

A smooth band of graduated hues from blue to cyan is displayed across the bottom of the monitor screen. (These are pure HSV hues of $S=1$ and $V=1$.) If the display system is not capable of continuous hues, a number of discrete color boxes will allow the same activity. To select a color, the operator uses the stylus to signal Hue Select or Hue Range from the main menu. Hue Select is a direct choice, indicated by locating the color in the hue band and depressing the stylus at the desired point. Hue Range allows the indication on two points on the hue display, with the subsequent feedback of a new hue display using the selected hues as endpoints. Hue Range precedes Hue Select in cases where a finer choice of hue is desired. A second stylus "hit" on the Hue Range option returns the standard palette to the screen. Hue Select, triggered with the tablet stylus, allows selection of the next hue.

To complete the composition of a color, the hue must be modified by changing value and saturation. To accomplish this, the system displays a large swatch of the newly selected hue (see figure 7), with scales labeled Saturation and Value (or Tint and Shade) arranged along two edges of the swatch. Motion of the cursor within the swatch causes changes in its value and saturation relative to the position of the cursor.

Depressing the stylus at any point within the swatch selects the value and saturation, thereby defining the color. The swatch and the value and saturation scales are wiped from the screen, and the system writes a small segment of the color at the left of the hue band, with an index beneath it to identify it. This process continues as long as the operator wishes, within the number of available indexes. (The number of available indexes, equal to the number of simultaneously displayable colors, is directly related to the word length or *bit depth* of the frame buffer. These hardware constraints are discussed below.)

Later references to a color are possible by pointing to any area of the screen where that color resides or by referring to the color's index via the keyboard. Indexing colors makes it possible to call particular ones to the screen for comparison to colors being mixed. As an option, mnemonics could be added to make the indexes easier to use.

Given one or two initial colors, the system should be able to suggest *harmonic* sets of up to six colors. Harmonic colors have a balanced, pleasing relationship with each other; harmonic relationships are discussed later in the section on color harmony.

System software should allow you to select colors via some index system relating the monitor hues to the hues of other output devices, such as film recorders and color printers. This interactive procedure is tedious and dependent on the particular hardware chosen. Short of a one-to-one color mapping (in which every color on the monitor can be represented on another output device—a difficult task to manage), the most important factor is the preservation of harmonic relationships.

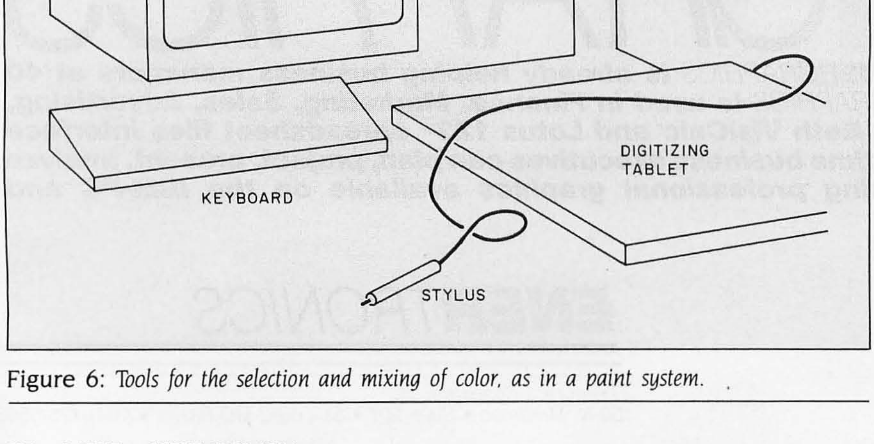

Figure 6: *Tools for the selection and mixing of color, as in a paint system.*

A most important capability of a color system is color mixing. User dialogue for mixing begins when the Mix option is chosen from the menu, followed by a Pick of two colors. The two selected colors are then displayed as shown in figure 8, with an equal space for their mixture between them.

Motion of the cursor on a line between the picked colors will result in a weighted mixing, with the (real-time) result shown in the intervening square. This method is superior to choosing all of the colors from a predefined palette, as a definite relationship between selected colors is assured.

Another necessary feature of a color system is the selection of complementary hues. In HSV, complements of hue are opposite each other (180 degrees away) on the $V=1$ plane (see figures 3 and 4). Choosing the H*comp* (hue complement) option followed by selection of a hue will instruct the system to compute and display the complementary hue. The distinction between an *algorithmic* color system, such as this one, and *perceptual* color systems, is a crucial one. As mentioned earlier, no truly representative model for human color vision exists.

COLOR HARMONY

There are some simple and some very complex rules for selecting harmonic colors. A definition of harmonic color is imprecise at best, as color is highly subjective. As Johannes Itten states, "The idea of color harmony is to discover the strongest effects by correct choice of antitheses". It is a basic fact of human vision that colors are enhanced by their complements. Anyone who has stared at a color, then turned his gaze to a light-colored surface, has experienced an action of complementary colors called "successive contrast."

The visual sum of the visible spectrum is white light. If the spectrum is divided at any point, the two parts will be perceived as complementary colors. The remixture of any such complementary pair will be white or light gray. (Therefore, the simplest harmonic choice is what Itten termed the *dyad*: the complement, or direct opposite on the hue hexagon.)

The simplest approaches to finding harmonic colors are based on a few rules. First, use a small number of colors. For most information graphics, four or five colors will suffice. Choose a background color that is either a warm gray or the complement of one of the foreground colors. Be aware that colors have different "perceptual depth," that is, some colors seem to advance while others recede, particularly on monitors and in slides made from film recorders. Perceptual depth is due to the fact that various wavelengths of light actually focus at different distances from the lens of the eye. Blue, for example, requires noticeable refocusing and tends to recede.

Strong differences in visual depth can be fatiguing and distracting. Use groups of colors from one-half (or less) of the hue hexagon. This will lend a predominant tone to your graph or picture. Throw in a single color from the other side of the hue hexagon. Avoid using all pure hues: tinted or shaded colors appear more sophisticated to the eye. A series of gray tones is eloquent in its simplicity.

It is far wiser to begin using shades or tones of a single hue than with the color scheme of a child's tricycle. One simple harmonic form is the *tetrad*, two pairs of complements that are 90 degrees apart. Evenly spaced triadic forms (e.g., the primaries) often appear garish. Of the 1983 crop of microcomputers, few have sensible color systems. The worst offer four or eight colors of dubious parentage while the better of them offer four or eight, chosen from a range of up to 4K, (4096) colors. The only real need for a high-resolution display featuring 16 million colors is in three-dimensional shaded graphics.

As an example of a harmonic set of colors that could be suggested by a color graphics system, an initial hue specified by the user would lead to a tetrad of hues plus a dark and a light gray. If two complementary colors (not pure hues) were first specified by the user, such a tetrad could be chosen from an oblique plane intersecting the HSV hexcone.

We can now discuss some system methods for producing color groups. However, the notion of finding a color's complement at a point 180 degrees around an algorithmic model must first be made more precise. The user must be able to construct customized versions or adjustments of the HSV model. A graphics system with such an artist-calibrated color approach will allow the tailoring of key features of color operations. Such a procedure begins with the selection of perceived complements through the physical mixture of two colors on the monitor.

Since complementary colors of light mix to a light neutral gray or white, a pair of complements displayed from a common area of a monitor will have the same property. The system must, therefore, permit the direct mixing of actual colors on the screen for a determination of complements to take place. If a hue is specified through Hue Select, its complement can be found through invoking a *Defcomp* (define complement) option. The system then changes the hue band (figure 7) to a smaller range (some 30 degrees in hue) centered around the algorithmic complement. At the same time, a *summing swatch* will appear on the screen, an area in which both the original color and the complement

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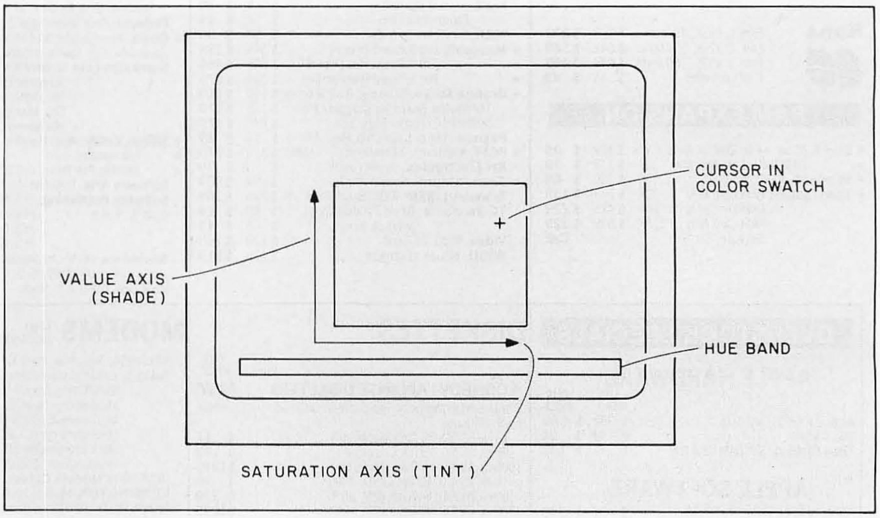

Figure 7: *Adjusting the value and saturation of a color from its basic hue.*

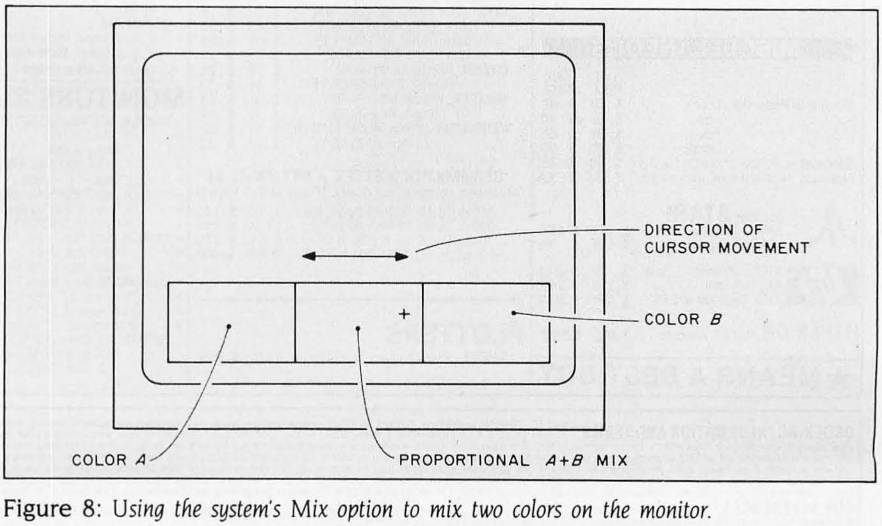

Figure 8: *Using the system's* Mix *option to mix two colors on the monitor.*

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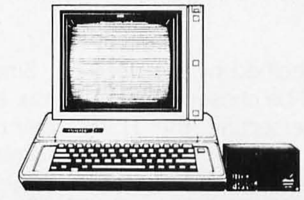

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Phoenix, Zoom Grafix	$ 40	$ 34
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Terrapin, Logo	$ 99	$ 65
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★ **Continental**, Home Accountant		$ 75	$ 49
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Hayden, Sargon III (Chess)		$ 50	$ 34
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Knoware, Knoware	NEW	$ 95	$ 64
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S.A.M.		$ 100	$ 67
Origin, Ultima III		$ 60	$ 40
Penguin, Transylvania	NEW	$ 35	$ 24
Scarborough/Lightning, Mastertype		$ 40	$ 27
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"Night Mission Pinball"		$ 40	$ 22
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TG, Tracball	$ 40	$ 24
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Lime	$ 90	$ 60
Peach	$ 98	$ 66
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Kensington, PC Saver™ Line Cord w/filter	$ 50	$ 39
NetworX, Wiretree, 4 outlet, w/filter-surge	$ 70	$ 32

for the ATARI

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KOALA, Pad w/Micro Illus.	$ 100	$ 75

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100 ea, DS/DD, 40 Track (IBM, H/P)		$ 239
1000 ea, DS/DD, 40 Track (IBM, H/P)		$1995
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212 Apple Cat, 1200 BAUD		$ 725	$559
Cat		$ 189	$139
J-Cat		$ 149	$104
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★ Quadscreen 17" 968x512		$1995	$1595
★ Quadchrome II, 14" RGB Color	NEW	$ 650	$450
★ Amberchrome, 12" Amber	NEW	$ 250	$165
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12" Color, ZVM135		$ 599	$499

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RX80, F/T			Call
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FX100, 160 cps		$ 895	Call
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★ **MANNESMANN** Spirit, 80 col 80cps		$ 399	$ 299
TALLY, 160L, 80 col. 160cps		$ 798	$ 568
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Microbuff In-Line 64K,Ser.		$ 349	$ 259
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★ **STAR MIC.**, Gemini 10"X, 120cps		$ 499	$ 289
Gemini 15"X, 120cps		$ 549	$ 439

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★ **TTX**, 1014, 13cps,Para.&Ser.,Pin&Fric,3p.	$ 499	$ 365
1114, same as 1014 with T/F, 2 col.&Prop.	$ 599	$ 439
MACpac, Interface TTX to Apple MAC		Call
★ **JUKI**, 6100, 18cps, Para, 3 pitch	$ 599	$ 459

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Microfazer, w/Copy, PP, 8K, #MP8 w/PS	$ 179	$ 139
Microfazer, w/Copy, PP, 64K, #MP64 w/PS	$ 299	$ 229
Microfazer, w/Copy, PP, 128K, w/PS	$ 375	$ 345
Microfazer, Snap-on, 8K, PP, Epson w/PS	$ 169	$ 129
Microfazer, Snap-on, 64K, PP, Epson w/PS	$ 299	$ 229

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	MegaPlus II, 256K, S/P/CC	$ 695	$ 595
	256K MegaPlus II Expander	$ 395	$ 295
	SixPakPlus, 64K, S/P/CC +S/W	$ 395	$ 265
	SixPakPlus, 256K,S/P/CC +S/W	$ 695	$ 495
	SixPakPlus, 384K,S/P/CC +S/W	$ 895	$ 595
	Game Port for SixPak	$ 50	$ 39
	I/O Plus II, S/P/CC	$ 215	$ 150
	I/O Plus II, S/P/CC/G	$ 265	$ 185
	I/O Plus II, 2S/P/CC/G	$ 315	$ 215
	MonoGraphPlus™P/CC(forLotus)	$ 495	$ 375
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	PCNet, Circuit Board, PC001		$495
*CCS	SuperVision, 132 col., mono. board	$ 799	$ 399
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	Chalkboard Starter Kit	$ 50	$ 34
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	3 to 9 foot keyboard cable	$ 40	$ 30
	Vertical CPU "System Stand"	$ 25	$ 19
	Monochrome Ext. Cable Pair	$ 50	$ 35
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Key Tronic	KB5150, Std. keyboard	$ 209	$ 159
	KB5151, Std. keyboard NEW	$ 255	$ 199
	KB5151 jr, keyboard NEW	$ 255	$ 199
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	Programmer's Guide	$ 15	$ 14
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	Memory Module 256K (MM256)	$ 422	$ 357
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	Color Board & Draftsman, 16 color, w/Para	$ 559	$ 395
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	Quadboard 64K, expand to 384K,S/P/CC	$ 395	$ 265
	Quadboard 256K, expand to 384K,S/P/CC	$ 675	$ 525
	★ Quadboard, 384K, S/P/CC	$ 795	$ 625
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	Quadboard II, 64K,expand to 256K,2S/CC	$ 395	$ 265
	Quadboard II, 256K, 2S/CC	$ 595	$ 395
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	Quadcolor I, board, 16 colors	$ 295	$ 215
	★ Upgrade Quadcolor I to II kit	$ 275	$ 199
	Quadvue, board, Mono/S/P/CC		Call
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	Quadchrome II, 14" RGB Color NEW	$ 650	$ 450
	Amberchrome, 12" Amber NEW	$ 250	$ 165
	Quad 3278, NEW	$1195	Call
	Quadnet VI, NEW		Call
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	Captain, 384K,S/P/CC	$ 795	$ 595
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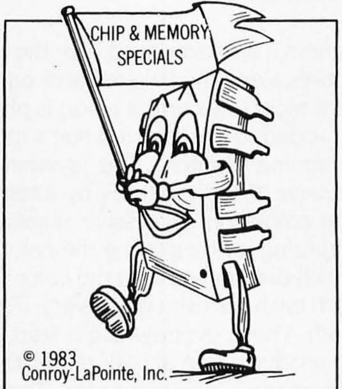

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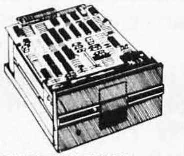

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ASHTON-TATE, dBase II	$ 495	$ 349
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DIGITAL RESEARCH, Full Line		Call
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	Friday		$ 295	$199
	ATI, Training Programs—Wide line in stock		$ 75	$ 50
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	BPI, Gen'l Acctg,AR,AP or PR, each		$ 595	$395
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	MailMerge™	SPECIAL	$ 250	$129
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	StarIndex™	SPECIAL	$ 195	$109
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BUSINESS & TRAINING

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	R:base Clout	NEW	$ 195	$129
	MONOGRAM, Dollars & $ense		$ 165	$110
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"guess" are overlayed. As the stylus moves along the palette band, each color it picks (the current color) is physically added to the selected hue within the summing swatch. The system may achieve these mixtures by alternating the colors on successive pixels, as in dithering, or by altering the color map, which determines what the color will be, with each refresh cycle (every 1/30 second). These overlays are a step closer to producing an actual, rather than an algorithmic, color mixture. The operator's goal during Defcomp is to mix the sum swatch to a light neutral gray. The pick hue at that point will be the perceived complement of the color passed to Defcomp. (Defcomp produces a model that is more perceptual than the purely algorithmic Hcomp option.) Depressing the stylus selects the hue, assigns an index to it, and stores it in a file (Fitfile) paired with the algorithmic estimate of the complement. This file is used as described below to obtain a tuning of the HSV-to-RGB transformation.

The transformation (or "transform") of HSV to RGB begins with the arbitrary assignment of the most intense blue ((r,g,b)=(0,0,1)) as (h,s,v)=(240 degrees, 1,1). This point is chosen since one electron gun is full on and the other two are off. The user interaction described in Defcomp will determine that the perceived complement of this blue is a yellow. Lying between red and green (figure 3), this yellow will require both the red and green guns to be turned on to some intensity. The blue gun will be turned off.

The Defcomp operation is then performed for red ((r,g,b)=(1,0,0)) and for green ((r,g,b)=(0,1,0)).

The system should provide for viewing the results of at least six completed Defcomp pairs simultaneously. This will allow comparison of the grays formed by mixing each complement pair and the adjustment of some of the pairs if needed (figure 9). Careful attention to this phase of complement definition will ensure that sensible color relationships are produced by the system and by the operator.

An option called Fitmodel, when selected, will perform a least-squares fit of the points in Fitfile and derive the tailoring function (the adjustment of HSV to perceptual behavior). An algorithmic HSV-to-RGB transform will operate as before, except that the initial HSV values will be tailored to account for the operator's complement choices. Now that the HSV-to-RGB transformation is closer to perceptual behavior, an algorithm can find acceptable color harmonies. The operator can expect proper mixing of colors, and the system will produce sensible results when calculating or adding colors.

An example of computed color mixes is *antialiasing*. (*Aliasing* refers to the stairstepping of lines and edges on monitor screens.) To remove the aliased or stairlike effect, boundary pixels are repainted with color values that are stepped "averages" of the colors on either side of the boundary. What is meant by an average color depends very much on the color model in which computations are being performed and on the model's closeness of fit to perceptual behavior. If, for example, an antialiasing routine selects three colors as intermediates and the model being used is RGB, it is probable that the colors will not be of the same value, and their harmonies may suffer in comparison with HSV or other cylindrical model computations.

Once Fitmodel has been invoked, the operator should test some more hues by calling Hcomp and testing the results with Defcomp to see if their mixture produces the same neutral gray as the others. If they do not, a few more complement pairs should be created via Defcomp. With these new points in Fitfile, the Fitmodel option will likely do a better job.

HARDWARE AND HUMAN FACTORS

The display of color imposes definite requirements on the hardware and software of a graphics computer system. The diagram in figure 10 is a generic architecture for a graphics computer and, through software, can be customized to the needs of different users.

The *frame buffer* in figure 10 is a section of dual-ported high-speed computer memory that allows read/write access by the computer and read access by the display controller. The frame buffer holds one video frame in digital form. Sometimes called the *picture memory*, the frame buffer represents two dimensions of spatial resolution and one dimension of color resolution (the bit depth).

For example, a system capable of dis-

(continued)

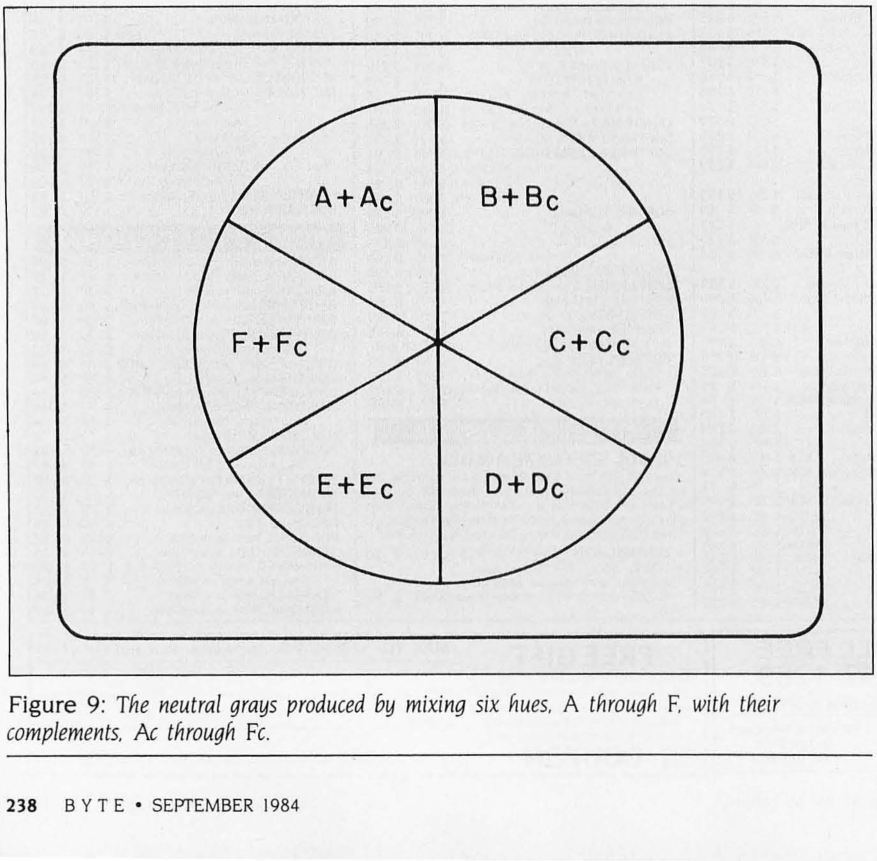

Figure 9: *The neutral grays produced by mixing six hues,* A *through* F, *with their complements,* Ac *through* Fc.

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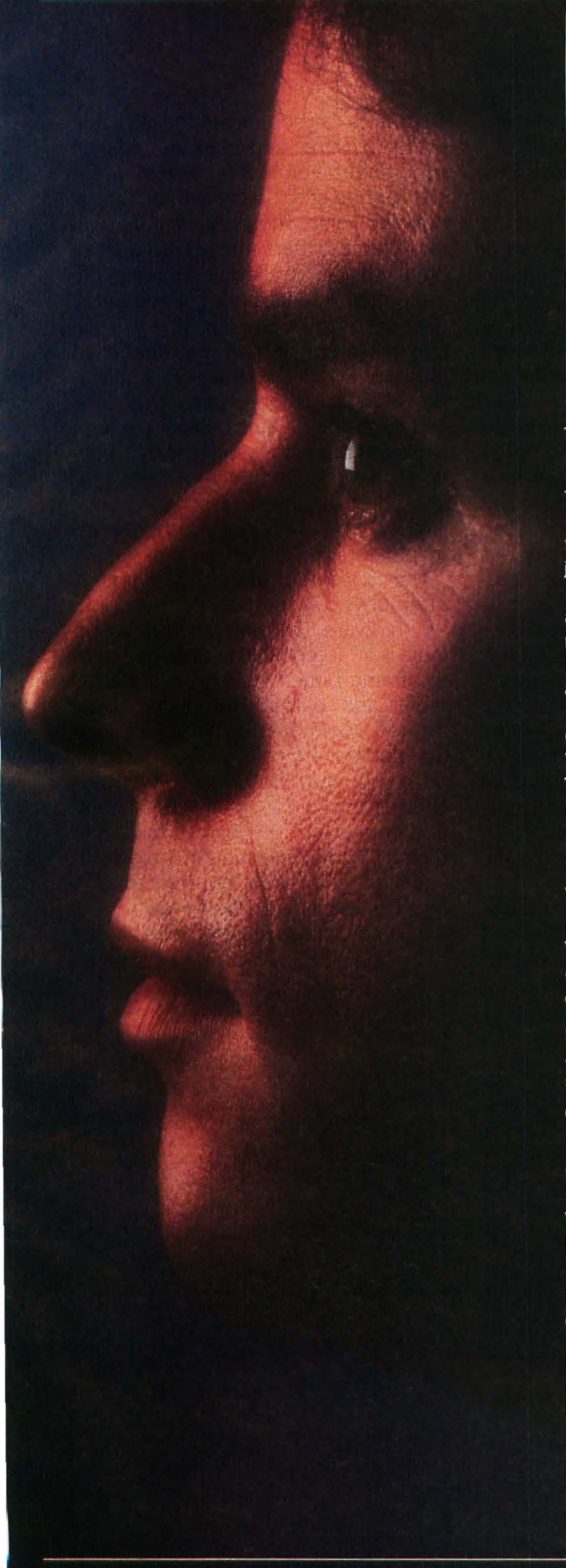

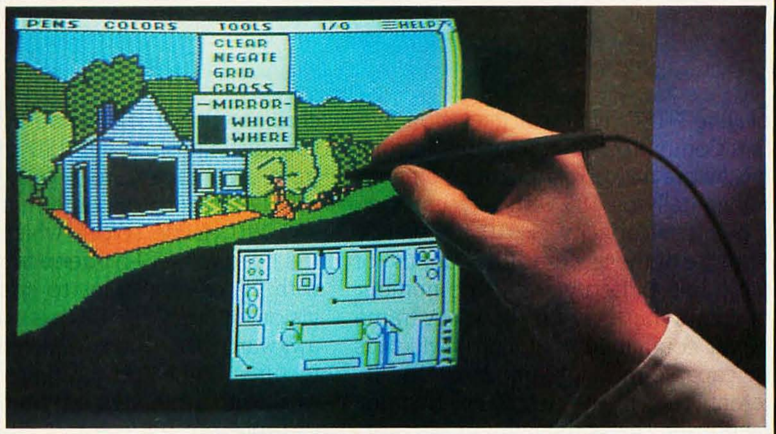

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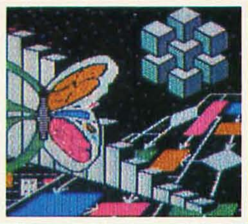

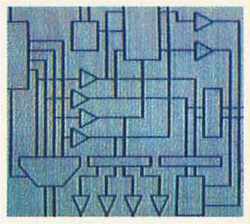

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playing NTSC (National Television System Committee) standard video format must store 640 pixels (picture elements) horizontally by 485 vertically, implying a memory capacity of 310,400 words. The size of these words (the "depth" of the frame buffer) governs the number of colors that may be shown. A frame buffer containing 4-bit words will thus be capable of displaying 2^4, or 16, different colors or gray values simultaneously. This is the number of colors that may be *shown*, which is a subset of the total number *available*. The color information stored in a frame buffer is usually RGB. It is also possible to store HSV or other color values in the frame buffer.

Suppose you are designing a system or some software that will offer color choices. It is not enough to simply decide that 8 bits of your 24-bit frame buffer will be devoted to red. Human vision has certain characteristics of color discretion that, if observed, will make system design more cost-effective.

The eye can distinguish over 350,000 colors. If a color varies only in hue, about 128 steps can be perceived. If colors vary only in value, most people can distinguish a minimum of 16 steps at the blue end of the spectrum and up to 23 steps in the yellow range. In the direction of saturation (also termed chromaticity or relative purity), the eye can distinguish some 130 gradations from gray to a pure hue. Multiplying 130×23×128 gives us a maximum of 382,720 visible colors, which leads to the need for a 19-bit-deep frame buffer with 2^{19} color choices to span human vision. Since 19 bits is somewhat awkward for most machine architectures, high-end graphics systems work with 3-byte (24-bit) frame buffers to represent full color.

These measurements were derived using paint samples compared under CIE illuminant D65 (see figure 1), a standard white light. The TV and color monitor gamuts are much smaller, hence they require fewer memory bits to store their characteristics. A reduced-color gamut for computer graphics having 128 hue gradations (requiring 7 bits), 16 value gradations (requiring 4 bits), and 8 gradations of saturation (requiring 3 bits) will adequately represent color behavior for most graphics applications. These 14 bits of HSV data translate directly into those needed by an RGB frame buffer. The total information capacity, the number of expressible colors (2^{14}, or 16,384) must be the same in both models.

On the low end of the scale, choosing HSV axis resolution for systems of fewer than 128 colors is fairly pointless. Operators can soon learn the available colors by rote, and a model will be superfluous. For an 8-bit system, use 4 bits for hue and 2 bits each for saturation and value. The problems of "shallow" frame buffers (those with a small bit depth) can be alleviated through the use of a lookup table (or color map), as described below. Systems that will display more colors than the number of available RGB indexes are often able to provide good color results with as little as 3-bit (8-color) frame buffers. The term *bit-mapped* refers to systems with a 1-bit-deep frame buffer. Such systems provide only two tones (or black and white). Apple's Lisa and Macintosh are examples of bit-mapped systems.

The *color lookup table*, or *color map*, is often physically part of the frame buffer hardware. The function of a lookup table is to accept RGB information from the frame buffer, search a translation table, and output the digital value located. Lookup tables will not change the number of colors displayable at once, but they do allow more color choices. In figure 10, 4-bit RGB information comes into the lookup table and 6-bit RGB color information is read out. This configuration is referred to as a "4-bit in, 6-bit out" color map.

One advantage of color maps is the

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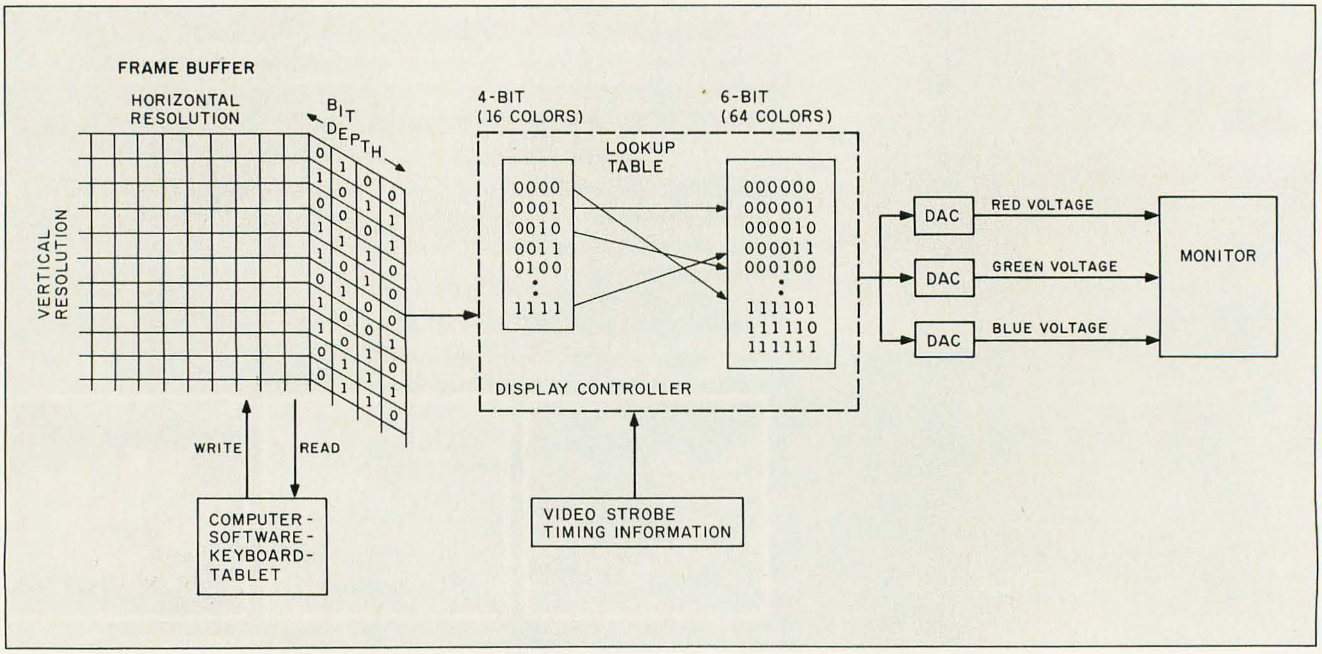

Figure 10: *Basic graphics hardware architecture.*

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ability to make global color changes. All the RGB indexes of a color in the frame buffer need not be individually located and recomputed to change the color: the color table's response to the index can simply be changed. The result is a global change of a particular color, which takes place within a screen-refresh cycle (the time it takes to "repaint" the screen, 1/30 second). Simple types of animation called color-table animation are also possible. And, as mentioned above, a lookup table will enhance the color model characteristics even in systems with shallow frame buffers by making a wider palette available. Remember that a good binary representation of HSV geared to human visual characteristics requires 14 bits. If a 3-bit system can map its frame buffer to a 14-bit RGB value, it will have eight simultaneous choices while maintaining a nearly optimal, artist-selected color range of over 16,000 colors.

The *display controller* is all of the hardware that reads the color intensity values in the frame buffer, consults the lookup table, and sends the information on to the *digital-to-analog* converters (DACs). The display controller must supply timing and synchronization pulses so that the pixels that are read from the frame buffer are scanned onto the display screen at the proper location.

The digital-to-analog converters are hardware devices that transform the digital RGB information into the actual electron-gun voltages required to produce color on the monitor. DACs output discrete voltage increments, with increment sizes inversely related to the size of color word (bit depth) they are designed to accept: the larger the color word, the finer the increments. Thus, an 8-bit color word providing 256 different choices might require each DAC to have six to eight discrete levels. DACs limit the color range. A computation that places two colors 6 percent apart in the red spectrum will have no meaning if there are only four steps in the (2-bit) DAC—the smallest increment acceptable to the DAC will be 100 percent ÷ 4, or 25 percent. Important parameters of DACs are linearity and number of steps; 2^Z distinct and equally spaced analog values are produced by a DAC of Z bits (or Z steps). For $Z > 8$, the color steps are fine enough to appear continuous.

The *monitor* includes electronics targeted at a particular task: scanning the entire surface of the screen with three independent electron beams and firing them at the RGB phosphor triads at each pixel location. Standard video refreshes (repaints) the screen approximately 30 times each second. Lower rates will cause the image to flicker, due to the fact that the persistence of the phosphors must be of short duration in order to allow clean movement. To refresh the entire screen, consisting of

(continued)

640 by 485 (or 310,400) pixels, 30 times each second, requires a switching speed in excess of the product 640 × 485 × 30, over 9.3 MHz. With 16 color choices (which requires 4 bits or one-half byte for each pixel), the information rate of the display controller is 640 × 485 × 30 × 0.5, or 4.66M bytes per second. Slower monitors must sacrifice either color resolution or spatial resolution. Monitors of 1000-line resolution with greater color capabilities require frequency bandwidths in the 50-MHz range. The fastest video monitors now available allow switching rates of 180 MHz, fast enough for full-color, 2000-line resolution. Plasma or liquid-crystal displays may prove superior, since scanning electronics will be replaced someday by steady-state pixel cells.

Consider the case of a graphics system using a 1024 by 768 frame buffer that is 8 bits (1 byte) deep. The information rate of the refresh circuitry is thus 23 megabytes per second (1024 × 768 × 30 × 1). Clearly, much information processing is required to merely refresh the display; flat-panel-type monitors will demand less processing.

COLOR SPACE TRANSFORMATIONS

Conversion between RGB and other color spaces is simplified by the fact that RGB is linear: familiar linear algebra operations work in this space, which means that transformation algorithms between RGB and HSV will be computationally inexpensive.

HSV TO RGB

If an adjustment scheme such as Fitmodel has been invoked, it is understood that the inputs to the transformation below are outputs from a tuning of HSV.

For hue H from 0–360°, with saturation S and value V on the range of real numbers between 0 and 1:

$$h' = H/60$$

h^* = greatest integer in h',

$f = h' - h^*$ (the fractional part of h')

$$p = (1-S)\times V$$
$$q = (1-S\times f)\times V$$
$$t = (1-(S\times(1-f)))\times V$$

Next, if $h^* = 0$, then ... $(r,g,b) = (V,t,p)$

$= 1 \quad = (q,V,p)$

$= 2 \quad = (p,V,t)$

$= 3 \quad = (p,q,V)$

$= 4 \quad = (t,p,V)$

$= 5 \quad = (V,p,q)$

RGB-TO-HSV TRANSFORM

To transform RGB color information into HSV;

MAX = maximum of R,G,B

MIN = minimum of R,G,B

d = MAX − MIN

V = MAX

if MAX is nonzero, set

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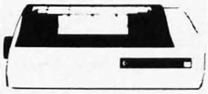

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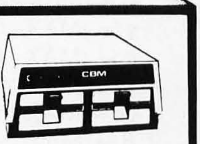

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$$S = d/\mathrm{MAX}$$

for MAX = 0, set $S = 0$ and H = undefined and return these values. Otherwise,

```
    $r = (\mathrm{MAX}-R)/d$
    $g = (\mathrm{MAX}-G)/d$
    $b = (\mathrm{MAX}-B)/d$
if $R = \mathrm{MAX}$ then set $h = b-g$
if $G = \mathrm{MAX}$ then set $h = r-b+2$
if $B = \mathrm{MAX}$ then set $h = g-r+4$
if $h < 0$, set $H = 60 \times h + 360$
if $h > 0$, set $H = 60 \times h$
```

SUMMARY

This discussion has centered on a basic computer graphics architecture from the perspective of color information storage, computation, and transmission through the system. Concepts of human visual perception and the problems of representing colors in man-made devices have been introduced. Most of the ideas suggested may be implemented on currently available microcomputer equipment. Color representation is among the most difficult problems in an exacting field. The desire to bring more attention to issues of color has been the motivation for this article. ■

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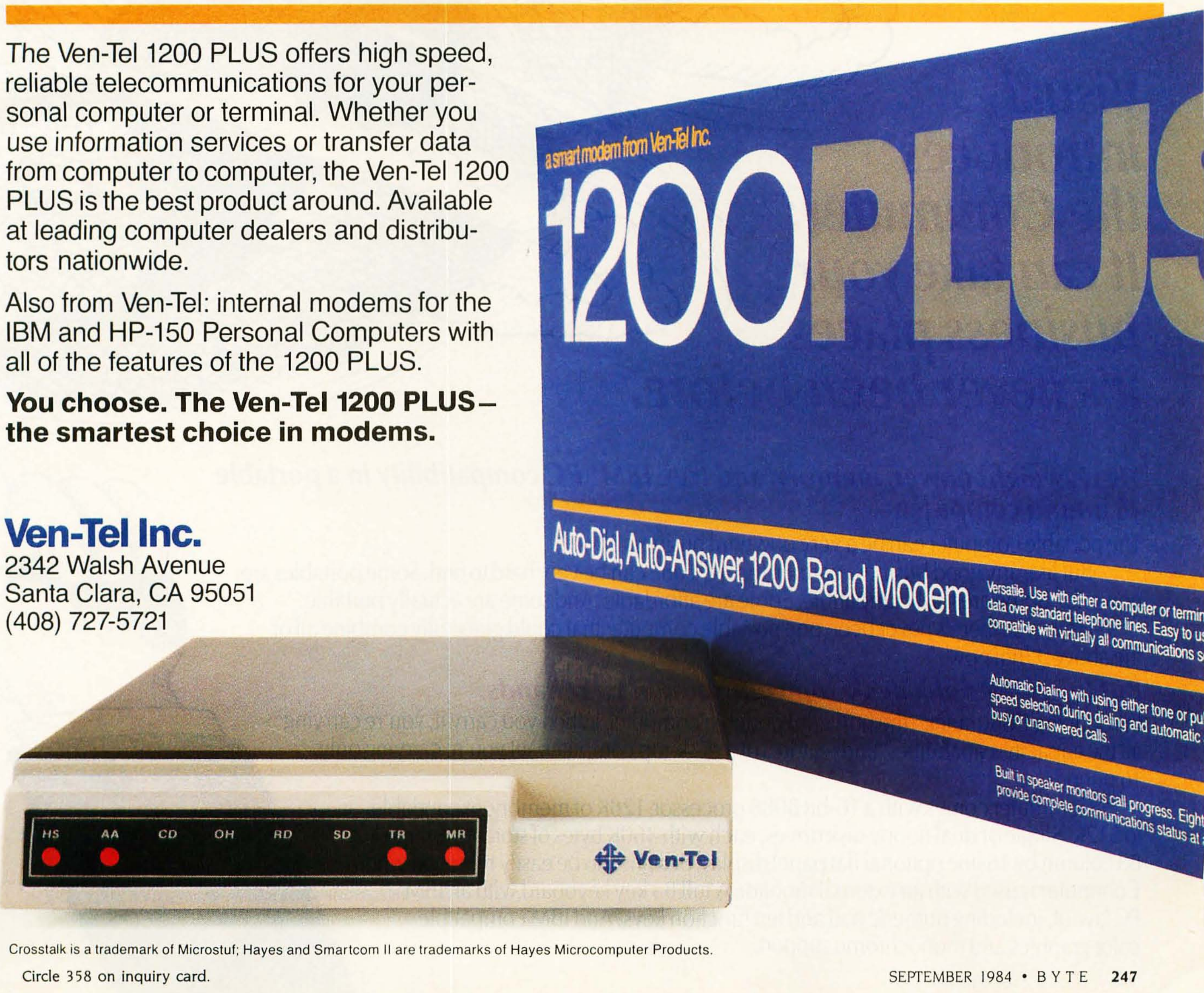

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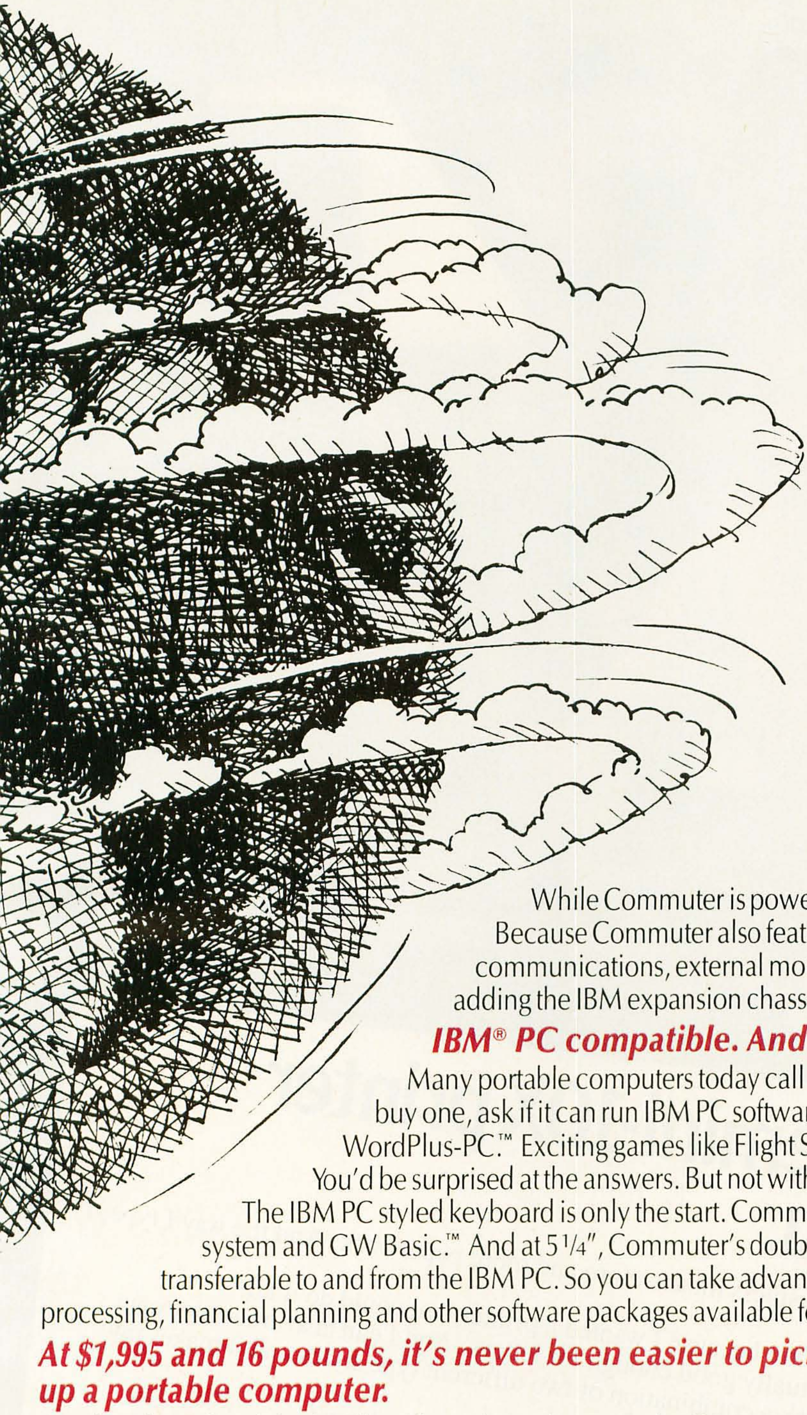

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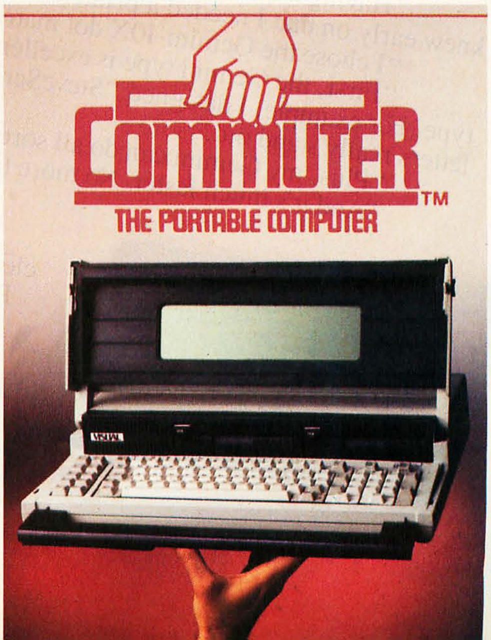

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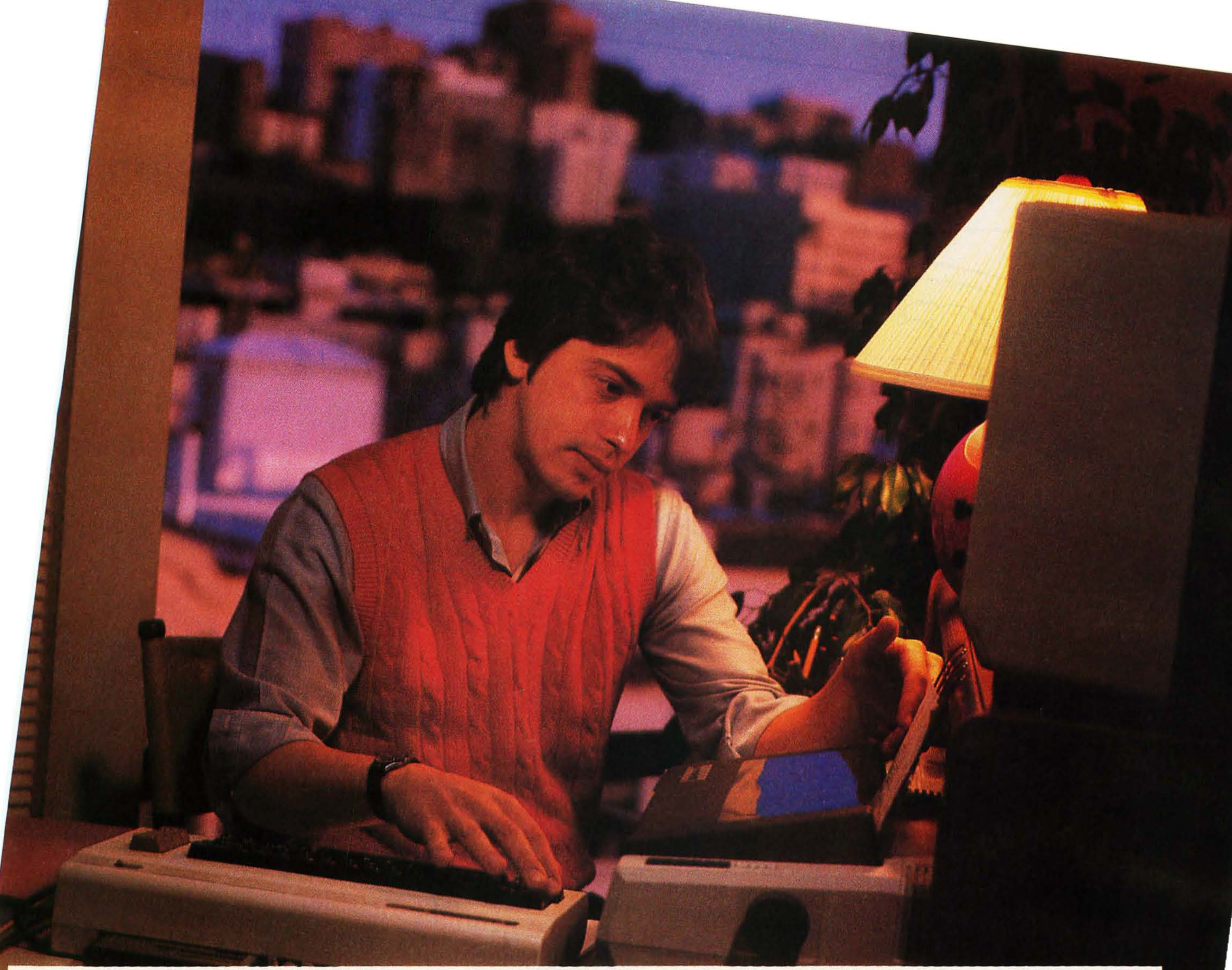

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REAL-TIME 3-D GRAPHICS FOR MICROCOMPUTERS

BY MARCUS NEWTON

A simplified drawing algorithm coded in assembly language permits 3-D animation in real time

AMONG A MICROCOMPUTER'S many applications, those involving sophisticated displays for animated graphics require the most speed and memory. A TV camera, via the straight paths of light waves, transforms a set of three-dimensional (3-D) coordinates (the visible points) into a set of two-dimensional (2-D) coordinates (the picture elements, or *pixels*). If you can effectively represent a portion of the 3-D world within a microcomputer's memory, you can produce a sequence of 2-D perspectives on the screen as you adjust the position, yaw, pitch, and roll of your hypothetical camera.

Typically, the trigonometry and floating-point mathematics of 3-D representation lead to less than adequate results. With them, the speed at which perspectives are generated is often not fast enough to simulate real time. Now, the NEC 3-D Video Synthesizer (3DVS) attempts to solve this problem by eliminating trigonometric functions and writing the resulting algorithm in 8086 assembly code using only 16-bit signed-integer arithmetic (see listing 1).

The 3DVS is designed to run under a CP/M-86 DOS (disk operating system) from Digital Research. It makes standard file and console calls that can easily be replaced by calls to another operating system. The code requires less than 3K bytes of memory and should be loaded as high as possible or put into ROM (read-only memory). The RAM (random-access read/write memory) data requirements depend on the size of the 3-D database, which can be saved and restored from disk. The target system also includes an NEC μPD7220 Graphics Display Controller (GDC), as found in the NEC Advanced Personal Computer (APC). A second version of the 3DVS supports the Motorola 6845, as found in the IBM PC. The 3DVS's Include file, GRAPHIC.A86, provides the code to drive any such graphic display device. The graphic display device need only support the routines INIT, CLEAR, SWAP, and PLOT. The PLOT routine can be as simple as an 80-character by 24-line cursor-positioning routine, or it can be implemented via a standard graphics package such as Digital Research's GSX. The target PLOT routine, GDCPLOT, also provided clipping and more than one clearing method. The high resolution of the GDC proved well worth the extra effort required to drive it.

When you look at a 3-D object, your line of sight forms a bundle of vectors beginning inside your eye and pointing to the visible parts of the object (see figure 1). The usual way to compute this perspective is to find the intersection of these lines of sight by putting a flat screen between your eyes and the object. The resultant image is called a drafting perspective. A more natural perspective is obtained by finding the intersection of the lines of sight with a sphere centered on your eye. This way, an object distends equally all around the screen no matter where it is located on the screen.

True perspective introduces horizontal and vertical vanishing points. Both of these types of perspective, as well as isometric projection, have been incor-

(continued)

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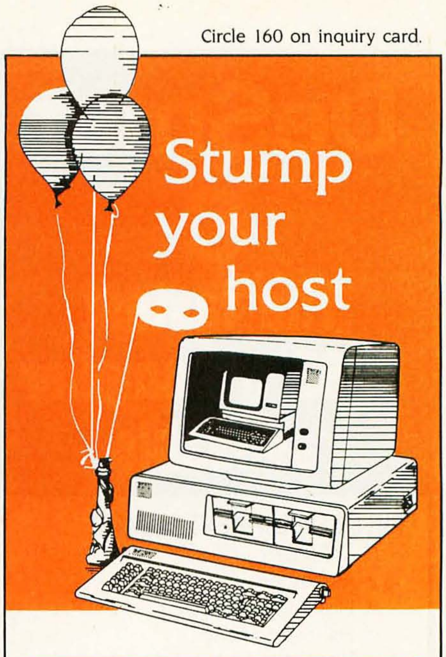
Listing 1: *Eliminating trigonometric functions and writing the resulting algorithm in 8086 assembly code using only 16-bit signed-integer arithmetic speeds the generation of three-dimensional perspectives to something approaching real time.*

```
;
;       The 3-D Video Synthesizer (3DVS) allows the user to create and view
;a three-dimensional artificial environment (3DAE). Parameters entered at the
;keyboard manipulate two three-dimensional points within the environment:
;(A,B,C) is the position of the user's eye or camera, the coordinates represent
;right, up, and forward. (D,E,F) is the orientation of his camera or the point
;he is looking at. This point will always appear in the middle of the screen.
;It is also the point he writes when the W parameter is nonzero. The only
;inherent limitation is that the camera cannot look straight up or straight
;down (i.e., A=D and C=F). In this case the system would literally not know
;what is up.
;
;       The parameters (A-W) are entered by typing the letter and an equal sign, followed
;by up to four hexadecimal digits. Less than four digits may be entered by follow-
;ing them with a carriage return, the high-order digits will be set to 0.
;All input parameters use two's-complement notation. The current value of any
;parameter may be examined by typing the letter followed by a question mark.
;
;       The write parameter (W) indicates by nonzero digits from left to
;right: Draw a vector from this point to the next (0 for single dot), Draw
;using RED, Draw using GREEN, Draw using BLUE. The color digits also indicate
;the pattern to be used (F = solid, etc.). Values higher than 1 in the first
;digit of W are reserved for higher-dimensional graphic primitives although
;not yet implemented.
;
;       For example, a YELLOW line may be drawn from (0,0,0) to (100,140,180)
; by the following two commands:
;
;               C=FA00(cr)      -to back off a little
;               W=1FF0(cr)      -yellow vector
;               (cr)            -do it
;               D=100(cr)
;               E=140(cr)
;               F=180(cr)
;               W=FF0(cr)       -yellow dot
;               (cr)            -do it
;
;       assuming all parameters were 0 to begin with.
;
;       Double letters may also be entered (AA - FF). These values are used
;to increment or decrement the corresponding single-letter parameters. The
;R parameter is used to indicate how many times to do so before further
;input is required. Thus, the camera or write point can be moved along any straight line un-
;assisted. RR reverses the sign of the double-letter parameters on count.
;Triple letters (AAA - FFF) are also allowed, which increment or decrement the
;double-letter parameters. Their effect is to move the camera or the write
;point in a circular or elliptical path without further keyboard input using
;the period parameter (RRR).
;
;       Circular or elliptical paths may be obtained in the x,y plane by the
;following formula:
;
;       Given x0, y0, dx, dy and n such that
;
;               (x0,y0) = center
;               n*n*dx = x diameter
;               n*n*dy = y diameter
;               4*n = number of points or vectors
;
;       Let     X = x0+n*n*dx/2,        Y = y0+n*dy/2
;               XX = 0,                 YY = n*dy
;               XXX = -dx,              YYY = -dy
;               R = 4n,     RR = 0,     RRR = 2n
;
;       Where X = A or D,               Y = B, C or E, F
;
;       For example, the camera can be moved in a horizontal circle about
;(0,B,0) by the following:
```

(continued)

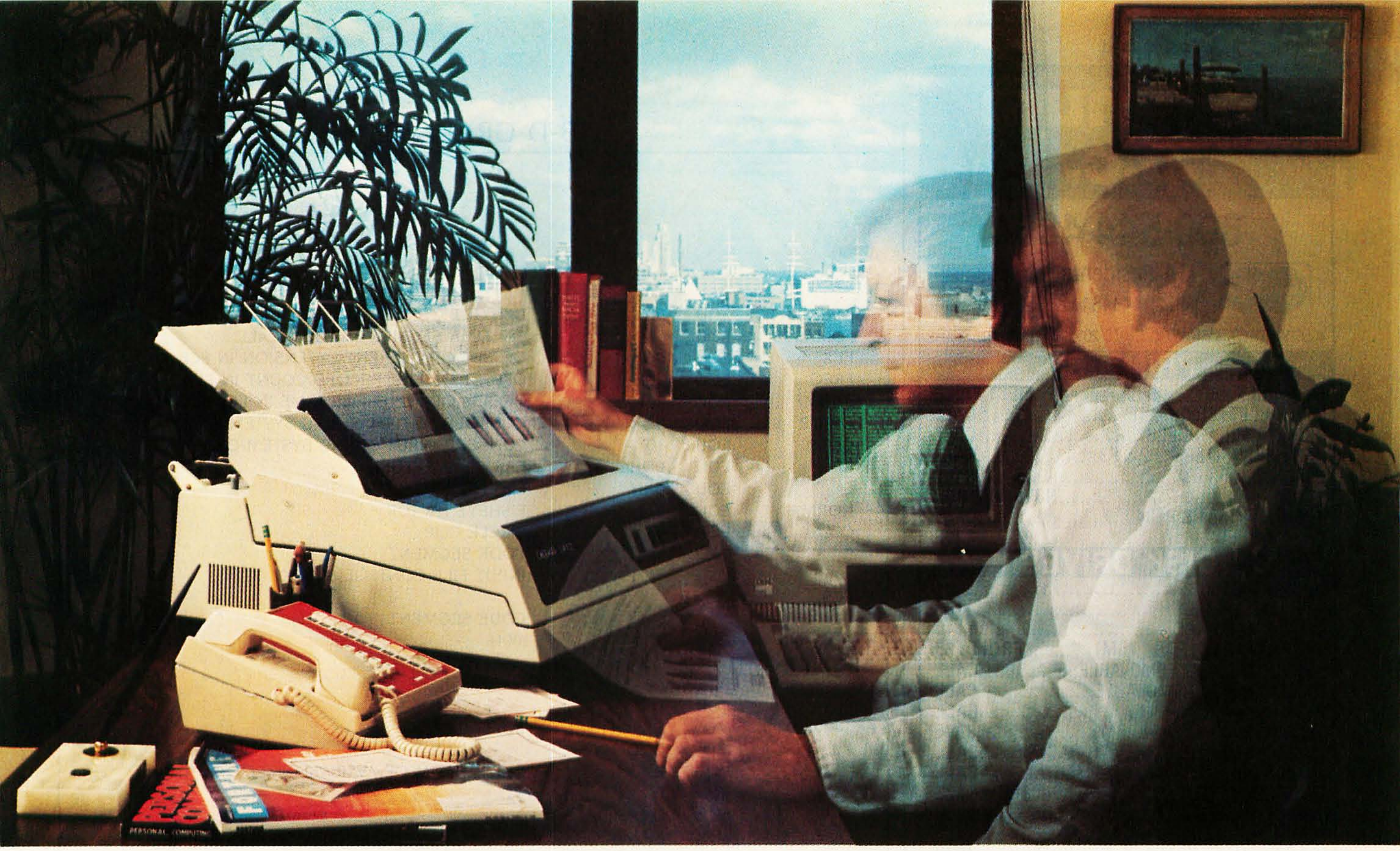
```
;
;          A=480(cr)
;          C=60(cr)
;          AA=(cr)
;          CC=C0(cr)
;          AAA=FFF0(cr)
;          CCC=FFF0(cr)
;          R=30(cr)
;          RR=(cr)
;          RRR=18(cr)
;
;     A 3DAE file, SPIRL, which draws itself, may be produced as follows:
;
;A=480(cr)       D=120(cr)    FF=4(cr)         DDD=FFF0(cr)   R=C0(cr)
;C=C0(cr)        E=30(cr)     AAA=FFC0(cr)     EEE=FFF0(cr)   W=10FF(cr)
;CC=180(cr)      EE=60(cr)    CCC=FFC0(cr)     RRR=C(cr)      (cr)
;
;     None of these double- or triple-letter parameters are displayed auto-
;matically, but any may be examined by typing the name followed by a question
;mark.
;
;
;     The rightmost digit of P, the perspective parameter, determines:
;
;          0 = true      1 = drafting      2 = isometric
;
;The low-order 4 bits of P are reserved for use by the PERSP routine. The
;high-order bits are available for controlling options within the display
;driver. See GRAPHIC.DOC.
;
;
;     Two single-letter commands, Z and U, have specialized functions:
;
;          Z causes all double- and triple-letter parameters to be set
;     to 0. This disables any real-time programmed motion.
;
;          U causes the last point written (via W) to be deleted from
;     the 3DAE. This is always the last point in the file.
;
;     The G and S commands, followed by a filename, allow new files to be
;appended to the current 3DAE (G) or the 3DAE to be saved (S) on disk under
;a new name. VIDEO may be invoked with a filename, in which case the run-time
;parameters are also read from disk.
;
;
;     The 3DAE file DOTCUBE may be produced by the following:
;
;C=FA00(cr)      EE=(cr)         FF=(cr)          EE=10(cr)       (cr)
;W=F0(cr)        DD=10(cr)       R=20(cr)         (cr)            D=100(cr)
;R=20(cr)        (cr)            DD=FFF0(cr)      EE=(cr)         F=FF10(cr)
;D=100(cr)       DD=(cr)         (cr)             R=1F(cr)        FF=10(cr)
;E=100(cr)       EE=10(cr)       DD=(cr)          D=FF00(cr)      (cr)
;F=100(cr)       (cr)            EE=FFF0(cr)      F=FF10(cr)      W=(cr)
;DD=FFF0(cr)     EE=(cr)         (cr)             FF=10(cr)       R=(cr)
;(cr)            R=1F(cr)        EE=(cr)          (cr)            Z(cr)
;DD=(cr)         F=F0(cr)        DD=10(cr)        E=FF00(cr)      (cr)
;EE=FFF0(cr)     FF=FFF0(cr)     (cr)             F=F0(cr)        SDOTCUBE(cr)
;(cr)            (cr)            DD=(cr)          FF=FFF0(cr)
;
;     The 3DAE file SPHERE may be partially produced by the following:
;
;C=FA00(cr)      R=(cr)          W=1FA5(cr)       RRR=(cr)        (cr)
;W=1FA5(cr)      W=FA5(cr)       R=10(cr)         D=40(cr)        R=(cr)
;R=10(cr)        (cr)            D=100(cr)        E=40(cr)        W=FA5(cr)
;RRR=8(cr)       W=1FA5(cr)      E=FFC0(cr)       F=100(cr)       EEE=FFE0(cr)
;D=100(cr)       R=10(cr)        F=40(cr)         DD=(cr)         (cr)
;E=40(cr)        D=100(cr)       DD=(cr)          EE=80(cr)       W=1FA5(cr)
;F=40(cr)        F=FFC0(cr)      EE=(cr)          FF=(cr)         R=4(cr)
;EE=80(cr)       DD=(cr)         FF=80(cr)        DDD=(cr)        D=FFC0(cr)
;DDD=FFE0(cr)    EE=80(cr)       EEE=(cr)         EEE=FFE0(cr)    E=40(cr)
;EEE=FFE0(cr)    FF=(cr)         FFF=FFE0(cr)     FFF=FFE0(cr)    F=100(cr)
;(cr)            EEE=FFE0(cr)    (cr)             (cr)            EE=80(cr)
;EE=(cr)         FFF=(cr)        R=(cr)           FFF=20(cr)      FF=(cr)
```

(continued)



```
;FF=80(cr)       (cr)           W=FA5(cr)     (cr)            (cr)
;EEE=(cr)        R=(cr)         (cr)          EEE=20(cr)      .
;FFF=FFE0(cr)    W=FA5(cr)      W=1FA5(cr)    (cr)            .
;(cr)            (cr)           R=4(cr)       FFF=FFE0(cr)    etc
;
;     Parameters may be entered only when the program stops. It may be
;exited by a Control-C (^c) (preceded by a BREAK (^s) if running) and the
;3DAE file may be edited by SID86 (or DDT86) at 200. It can then be
;saved in a VIDEO-compatible manner by W<filename>, 100, <length>. Or,
;having loaded VIDEO into memory, the program may be reentered at START by
;G13E (see also the utility programs MOVE and COLOR).
;
;                          3DVS COMMAND SUMMARY
;
;
;     Invocation:              enter     VIDEO(cr)   or VIDEO filename(cr)
;
;
;     Control:                 enter     <command>
;
;
;
;
;     <command> :=       (cr) | U(cr) | Z(cr) | (^c) | (^s) |
;
;                        <param>?(cr)| <param>=<hex>(cr) |
;
;                        G<filename>(cr) | S<filename>(cr)
;
;     <param>     :=     A | B | C | D | E | F | R | P | W |
;
;                          AA | BB | CC | DD | EE | FF | RR |
;
;                        AAA | BBB | CCC | DDD | EEE | FFF | RRR
;
;     <hex>       :=     | <hd> |< hd><hd> | <hd><hd><hd> |
                         <hd><hd><hd><hd>
;
;     <hd>        :=     0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
;
;                        A | B | C | D | E | F
;
;                             PROGRAM INDEX
;
;      VIDEO     - Initialization and parameter input
;      CAMERA    - Display sequence of perspectives
;      PERSP     - Apply OTM to all points producing perspective
;      ISQRT     - Find integer square root of double (32-bit) integer
;      INORM     - Normalize a vector component to unit sphere
;      SETFCB    - Move given filename into CP/M File Control Block
;      INFILE    - Read given 3DAE file from disk
;      OUTFILE   - Write 3DAE to disk under given filename
;      ATOH      - Convert ASCII to HEX
;      HTOA      - Convert HEX to ASCII
;      PRINT     - Output the values A,B,C,D,E,F,R,P, and W to the console
;
;                The following routines must be supplied by the user
;                for the particular graphic display system employed
;                            (see GRAPHIC.DOC).
;
;      INIT      - Initialize the graphics display device
;      CLEAR     - Clear the inactive display area (previous picture)
;      SWAP      - Start using other display area at retrace
;      PLOT      - Plot current point or draw vector from previous point
;
;**************************************************************************
;     INTERACTIVE THREE-DIMENSIONAL MODELING SYSTEM     NEC 8/18/83  M. Newton
;
BDOS       EQU    224         ;CP/M BDOS INTERRUPT VECTOR
FOPEN      EQU    15          ;FILE OPEN SYSTEM CALL
FCLOSE     EQU    16          ;FILE CLOSE SYSTEM CALL
FDELETE    EQU    19          ;FILE DELETE SYSTEM CALL
FREAD      EQU    20          ;FILE READ SYSTEM CALL
FWRITE     EQU    21          ;FILE WRITE SYSTEM CALL
FMAKE      EQU    22          ;FILE CREATE SYSTEM CALL
FDMAO      EQU    26          ;SET DMA OFFSET SYSTEM CALL
```

(continued)



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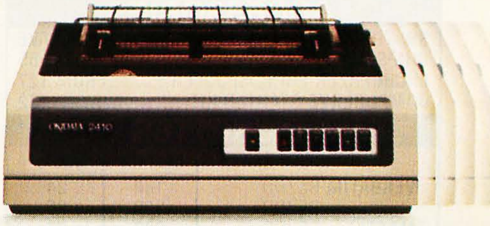

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```
DIRECT      EQU   50         ;DIRECT BIOS SYSTEM CALL
FDMAS       EQU   51         ;SET DMA SEGMENT SYSTEM CALL
FEX         EQU   0CH        ;OFFSET OF CURRENT EXTENSION IN FCB
FREC        EQU   20H        ;OFFSET OF FILE RECORD COUNT IN FCB
FNAME       EQU   24H        ;OFFSET OF INPUT FILENAME IN FCB
COSTR       EQU   9          ;CONSOLE OUTPUT STRING SYSTEM CALL
CISTR       EQU   10         ;CONSOLE INPUT STRING SYSTEM CALL
CR          EQU   0DH        ;CARRIAGE RETURN
LF          EQU   0AH        ;LINEFEED
NORM        EQU   512        ;FISHEYE FACTOR
CCLIP       EQU   16         ;CIRCLE CLIP
            CSEG             ;CODE SEGMENT
            ORG   5CH        ;INPUT FILE CONTROL BLOCK
FCB:
                             ;CODE SEGMENT
            ORG              100H

            PUSH  CS
            POP   DS,
            MOV   DX, OFFSET GETBOT
            MOV   CL,DIRECT
            INT   BDOS       ;GET BOTTOM OF AVAILABLE MEMORY
            INC   BX
            MOV   DX,SS:[BX]
            MOV   MEMBOT,DX
            XOR   AX,AX
            MOV   BX,OFFSET FCB
            CMP   FNAME[BX],AL  ;3DAE FILE DESIRED?
            JE    NOFILE     ;NO, START NEW 3DAE
            MOV   FREC[BX],AL   ;READ FROM FIRST RECORD
            MOV   BX,OFFSET A   ;STARTING AT FIRST VARIABLE
            CALL  INFILE
            JMPS  START
NOFILE:     MOV   DS,MEMBOT
            MOV   BX,OFFSET A
            MOV   CX,80H
            MOV   [BX],AX    ;ZERO LOCAL VARIABLES
            INC   BX
            INC   BX
            LOOP  $-4
            MOV   BX,OFFSET POINTS
            MOV   6[BX],AX   ;ZERO FIRST PIXEL
START:      MOV   DS,MEMBOT
            XOR   AX,AX
            MOV   BX,OFFSET POINTS
            MOV   -2[BX],AX  ;ZERO PREVIOUS PIXEL
            MOV   BX,OFFSET OUTBUFF ;CLEAR CONSOLE OUTPUT BUFFER
            MOV   AX,'
            MOV   CX,40
            MOV   [BX],AX
            INC   BX
            INC   BX
            LOOP  $-4
            CALL  INIT       ;INITIALIZE DISPLAY DEVICE
            CALL  PERSP      ;GENERATE PERSPECTIVE
            CALL  SWAP       ;FIRST DISPLAY REFRESH AREA
            CALL  PRINT      ;PRINT PARAMETERS
;--------------------------------------------------------------
VIDEO:      MOV   BX,OFFSET INBUFF ;INPUT PARAMETER FROM KEYBOARD
            MOV   BYTE PTR [BX],80 ;INPUT STRING MAX
            MOV   DX,BX
            MOV   CL,CISTR
            INT   BDOS       ;INPUT STRING FROM CONSOLE
            MOV   BX,OFFSET INPUT+1
            MOV   AL,[BX]
            CMP   AL,0       ;CONTINUE?
            JNE   VID10      ;NO, SET PARAMETER
            CALL  CAMERA     ;DISPLAY CAMERA SEQUENCE
            JMPS  VIDEO
VID10:      XOR   AH,AH
            MOV   SI,AX
            INC   BX
```

(continued)

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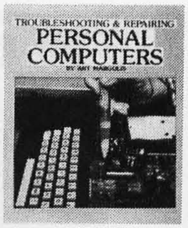

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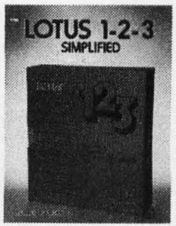

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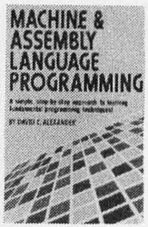

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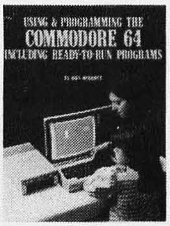

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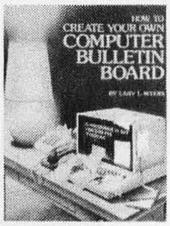

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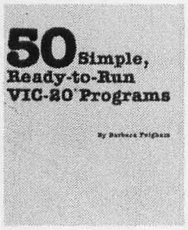

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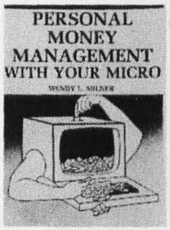

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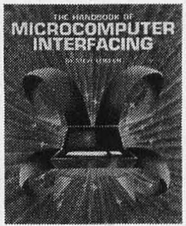

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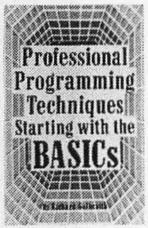

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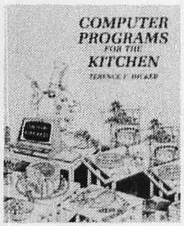

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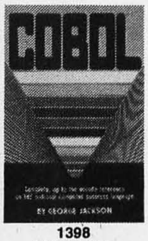

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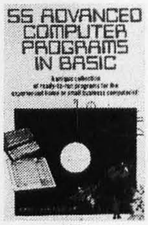

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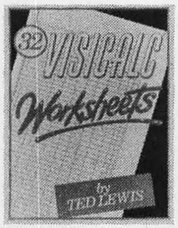

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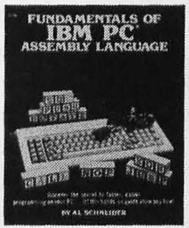

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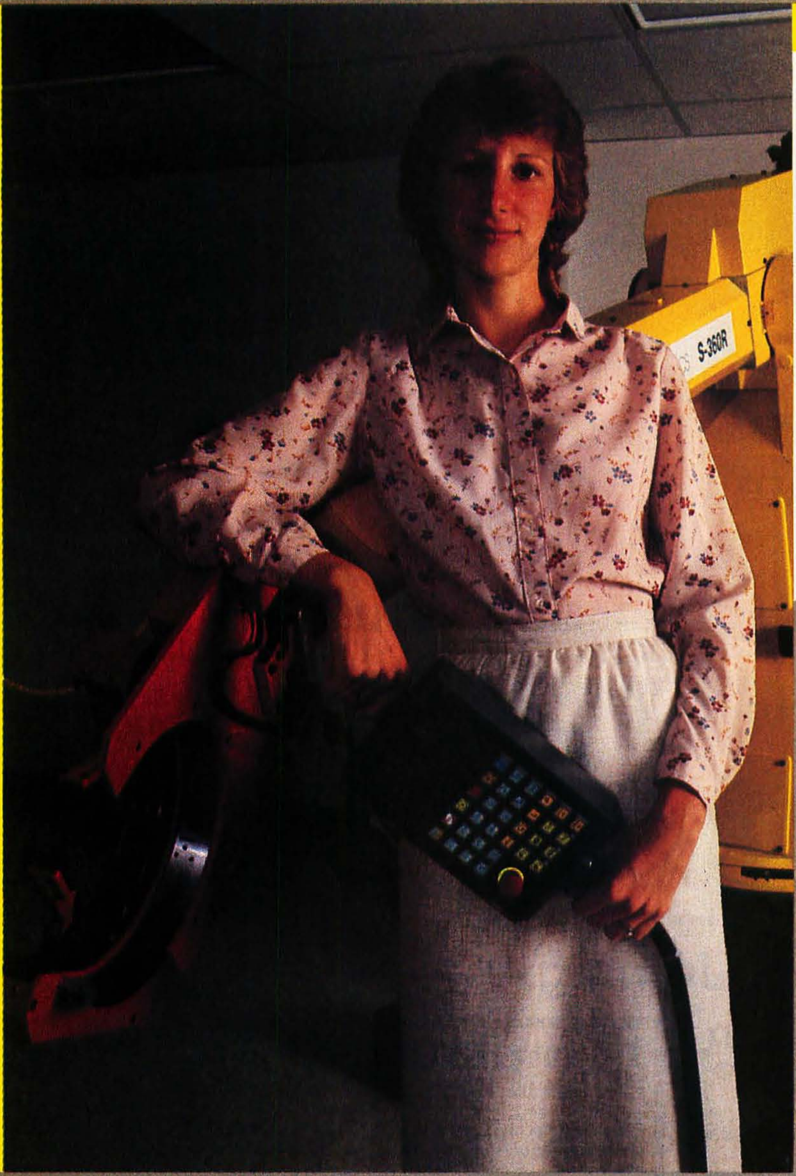

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```
         MOV    [BX+SI],AH         ;END OF INPUT
         MOV    AL,[BX]
         CMP    AL,'G'             ;GET ANOTHER FILE?
         JNE    VID15              ;NO
         CALL   SETFCB             ;PUT FILENAME INTO FCB
         PUSH   CS
         POP    DS
         MOV    BX,OFFSET FCB
         MOV    BYTE PTR FREC[BX],2 ;READ FROM THIRD RECORD
         MOV    DX,ENDSEG          ;APPEND TO CURRENT 3DAE
         MOV    BX,ENDPOINT
         CALL   INFILE
         MOV    DS,MEMBOT
         CALL   CLEAR              ;CLEAR INACTIVE DISPLAY AREA
         CALL   PERSP              ;GENERATE PERSPECTIVE
         CALL   SWAP               ;SWAP ACTIVE DISPLAY AREAS
         CALL   PRINT              ;PRINT PARAMETERS
         JMPS   VIDEO
VID15:   CMP    AL,'S'             ;SAVE 3DAE?
         JNE    VID20              ;NO
         CALL   SETFCB             ;PUT FILENAME INTO FCB
         PUSH   CS
         POP    DS
         MOV    BX,OFFSET FCB
         MOV    BYTE PTR FREC[BX],AL ;WRITE TO RECORD ZERO
         MOV    DX,MEMBOT
         MOV    BX,OFFSET A
         CALL   OUTFILE
         MOV    DS,MEMBOT
         JMP    VIDEO
VID20:   CMP    AL,'W'             ;SET WRITE MODE?
         JNE    VID30              ;NO
         MOV    SI,OFFSET W
         JMPS   VID70
VID30:   CMP    AL,'R'             ;SET REPEAT FACTOR?
         JNE    VID40              ;NO
         MOV    SI,OFFSET R
         JMPS   VID70
VID40:   CMP    AL,'P'             ;SET PERSPECTIVE?
         JNE    VID50              ;NO
         MOV    SI,OFFSET P
         JMPS   VID70
VID50:   CMP    AL,'U'             ;UNDO LAST POINT (ERASE)?
         JNE    VID55              ;NO
         MOV    ES,ENDSEG
         MOV    DI,ENDPOINT
         SUB    DI,8
         MOV    ENDPOINT,DI
         CMP    DI,-8
         JNE    VID54
         MOV    AX,ES
         SUB    AX,1000H
         MOV    ENDSEG,AX
         MOV    ES,AX
VID54:   XOR    AX,AX
         MOV    ES:6[DI],AX        ;ZERO PIXEL
         JMP    VIDEO
VID55:   CMP    AL,'Z'             ;ZERO 1ST AND 2ND DERIVATIVES?
         JNE    VID60              ;NO
         XOR    AX,AX
         MOV    BX,OFFSET AA
         MOV    CX,16
         MOV    [BX],AX            ;ZERO AA THROUGH RRR
         INC    BX
         INC    BX
         LOOP   $-4
         JMP    VIDEO
VID60:   CMP    AL,'A'
         JB     VIDERR
         CMP    AL,'F'
         JA     VIDERR
```

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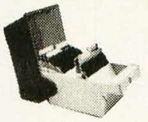

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SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	**16**	.59

Part No.	**Pins	Price
SN74156N	16	.59
SN74157N	**16**	**.59**
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.95
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	1.19
SN74184N	16	2.49
SN74185N	16	2.49
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

74LS00	14	.25
74LS01	14	.25
74LS02	14	.29
74LS03	14	.25
74LS04	14	.35
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	**14**	**.29**
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.39
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55

74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.89
74LS125	14	.59
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.89
74LS139	16	.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.29
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.95
74LS190	16	.89
74LS191	16	.89

74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.49
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	2.49
74S86	14	.55
74S112	16	.55
74S113	14	.55

74S114	14	.55
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	1.19
74S175	16	1.19
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49

74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	1.19
74S280	14	1.95
74S287*	16	1.95
74S288*	16	1.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	5.95
74S472*	20	4.95
74S473*	20	4.95
74S474*	24	4.95
74S475*	24	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

CA—LINEAR

CA3010H		1.35
CA3039H		1.35
CA3046N	14	1.35
CA3059N	14	2.95
CA3060N	16	2.95
CA3065E	14	1.49
CA3080E	8	.89

CA3081N	16	.99
CA3082N	16	1.19
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.49

CA3130E	8	.89
CA3140E	8	.79
CA3160H		1.95
CA3161E	16	2.95
CA3162E	16	6.95
CA3189E	16	1.59
CA3401N	14	.59

CD—CMOS

CD4000	14	.29
CD4001	14	**.29**
CD4002	14	.29
CD4006	14	1.19
CD4007	14	.29
CD4009	16	**.59**
CD4010	16	.59
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	1.19
CD4015	16	**.39**
CD4016	14	.49
CD4017	16	1.19
CD4018	16	.99
CD4019	16	.59
CD4020	16	1.19
CD4021	16	1.19
CD4022	16	1.19
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	1.29
CD4030	14	.39
CD4034	24	2.49
CD4035	16	1.49

(More in Catalog)

CD4040	16	1.19
CD4041	14	1.19
CD4042	16	.89
CD4043	16	.79
CD4044	16	.79
CD4046	16	1.19
CD4047	14	1.29
CD4048	16	.59
CD4049	16	**.39**
CD4050	16	.39
CD4051	16	.99
CD4052	16	.99
CD4053	16	.99
CD4056	16	2.95
CD4059	24	7.95
CD4060	16	1.49
CD4066	14	.59
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	1.19
CD4078	14	.49
CD4081	14	**.29**
CD4082	14	.29
CD4093	14	.49

CD4098	16	1.95
CD4506	16	1.19
CD4507	14	1.19
CD4508	24	3.95
CD4510	16	1.29
CD4511	16	1.19
CD4512	16	1.19
CD4514	24	2.49
CD4515	24	2.49
CD4516	16	1.19
CD4518	16	1.19
CD4519	16	.59
CD4520	16	1.19
CD4526	16	1.49
CD4528	16	1.49
CD4529	16	1.69
CD4543	16	1.95
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.69
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
2650	40	MPU (2MHz)	9.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
MCS6502	40	MPU w/Clock (1 MHz)	5.95
MCS6502A	40	MPU with Clock and RAM (2Mhz)	6.95
MCS6502B	40	MPU w/Clock at 3MHz	9.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	11.95
6809E	40	CPU—8-bit (External Clock) 1MHz	14.95
INS8035N	40	MPU—8-bit	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	19.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8748	40	HMOS EPROM MPU	24.95

Z80, Z80A, Z80B, Z8000 SERIES

Z80	40	CPU (MK3880N)(780C) 2MHz	$3.95
Z80-CTC	28	Counter Timer Circuit	3.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80-DMA	40	Direct Memory Access Circuit	9.95
Z80-PIO	40	Parallel I/O Interface Controller	3.95
Z80-SIO/0	40	Serial I/O (TxCB and RxCB Bonded)	12.95
Z80-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80-SIO/9	40	Serial I/O	12.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-PIO	40	Parallel I/O Interface Controller	3.95
Z80A-SIO/0	40	Serial I/O (TxCB and RxCB bonded)	12.95
Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-SIO/9	40	Serial I/O	12.95
Z80B	40	CPU (MK3880N-6) 6MHz	9.95
Z80B-CTC	28	Counter Timer Circuit	12.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-PIO	40	Parallel I/O Interface Controller	12.95
Z8001	48	CPU Segmented	44.95
Z8002	40	CPU Non-Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6500/6800/68000 SERIES

MC6502A	40	MPU with clock and RAM (2MHz)	6.95
MC6520	40	Peripheral Inter. Adapter	4.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	14.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Int. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	9.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	7.95

8000 SERIES

INS8080A	40	CPU	2.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
8284	18	Clock Generator/Driver	6.50
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	29.95
FD1793	40	Single/Double Density (True)	29.95
FD1795	40	Dual Density/Side Select (Inv.)	29.95
FD1797	40	Dual Density/Side Select True	29.95

SPECIAL FUNCTION

DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM54240N	24	Asynchronous Transmitter/Receiver	5.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg VAC Fluor. Drvr. (20-pin pkg.)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins		Price
1103	18	1024x1 (300ns)	.99
4027	**16**	**4096x1 (250ns)**	**2.49**
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1 (200ns)	5.95 - 8/44.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	**22**	**2048x1 (365ns)**	.10
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
41256	16	256x1 (200ns)	65.00
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	1.95
2114	18	1024x4 (450ns)	1.49 - 8/9.95
2114L	18	1024x4 (450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4 (200ns)	1.75 - 8/11.95
2114L-2	18	1024x4 (200ns) L.P.	2.25 - 8/14.95
2147	18	4096x1 (70ns)	4.95
2148	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	2.95
5101	22	256x4 (450ns) CMOS	2.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-3	24	2048x8 (150ns) CMOS	5.95
HM6116P-4	24	2048x8 (200ns) CMOS	4.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8 (150ns) CMOS	43.95
HM6264LP-15	28	8192x8 (150ns) L.P. CMOS	49.95
27LS00	16	256x1 (80ns) L.P.	6.95
7489	16	16x4 (50ns) 3101	2.25
74C920	22	256x4 (250ns)	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6501)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
74S189	16	16x4 (35ns) 93405	1.95
74S200	16	256x1 (80ns) 93410	3.95
74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

PROMS / EPROMS

1702A	24	256x8 (1us)	4.95
2708	24	1024x8 (450ns)	3.95
2708-5	24	1024x8 (550ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	5.95
TMS2532	24	4096x8 (450ns) NMC2532	6.95
TMS2564	28	8192x8 (450ns)	14.95
TMS2716	24	2048x8 (450ns) 3 voltage	9.95
2716	24	2048x8 (450ns)	4.95
27C16	24	2048x8	21.95
2716-1	24	2048x8 (350ns)	5.95
2716Q-5	24	2048x8 (550ns)	4.49
2732	24	4096x8 (450ns)	6.95
2732A-3	24	4096x8 (300ns)	7.95
2732A-4	24	4096x8 (450ns) 21V	6.95
2732Q-4	24	4096x8 (550ns)	5.95
2758Q-A	24	1024x8 (450ns)	2.95
2764-4	28	8192x8 (450ns)	9.95
2764-3	28	8192x8 (300ns)	10.95
MM5204Q	24	512x8 (1us)	4.95
MCM68764	24	8192x8 (450ns)	24.95
27128	28	16,384x8 (450ns) 128K EPROM	29.95
74S188	16	32x8 PROM O.C. (6330-1)	1.49
74S287	16	256x4 PROM T.S. (6301-1)	1.95
74S288	16	32x8 PROM T.S. (6331-1)	1.95
74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	5.95
74S472	20	512x8 PROM T.S. (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S476	18	1024x4 PROM T.S.	6.95
74S478	24	1024x8 PROM T.S.	8.95
74S570	16	512x4 PROM O.C. (6305)	2.95
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74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM T.S. (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	2.95
82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM T.S. (27S21)	2.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
82S185	18	2048x4 PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8 (80ns)	14.95
DM87S180N	24	1024x8 PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4 PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4 PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4 PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8 PROM T.S. (82S191)	14.95

DATA ACQUISITION

DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
AY-5-1013A	**40**	**30K Baud Uart (TR1602)**	**3.95**

LOW PROFILE (TIN) SOCKETS

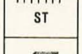
	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43

SOLDERTAIL (GOLD) STANDARD

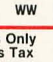
	1-9	10-99	100-up
8 pin SG	.30	.27	.25
14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08

LP

SG



ST



WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

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DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ . . . . $34.95 ea.
MM54104 Processor Chip . . . . $14.95 ea.

DT1057 - Expands the DT1050 vocabulary from 137 to over 260 words. Includes 2 ROMs and specs.
Part No. DT1057 . . . . $24.95 ea.

INTERSIL

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Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	16.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95

30009 1983 INTERSIL Data Book (1356p.) **$9.95**

NEW PRODUCT!

74HC High Speed CMOS

74HC00	14	.59
74HC02	14	.59
74HC03	14	.75
74HC04	14	.59
74HCU04	14	.65
74HC08	14	.59
74HC10	14	.59
74HC11	14	.59
74HC14	14	.85
74HC20	14	.59
74HC27	14	.59
74HC30	14	.89
74HC32	14	.75
74HC42	16	.99
74HC51	14	.75
74HC58	14	.75
74HC73	14	.79
74HC74	14	.79
74HC75	16	.89
74HC76	16	.79
74HC85	16	1.59
74HC86	14	.69
74HC107	14	.59
74HC109	16	.79
74HC112	16	.79
74HC113	14	.79
74HC125	14	.99
74HC132	14	.99
74HC137	16	1.95
74HC138	16	1.09

74HC139	16	.99
74HC147	16	1.19
74HC151	16	.89
74HC153	16	.99
74HC154	24	2.49
74HC157	16	.89
74HC158	16	.89
74HC160	16	1.29
74HC161	16	1.29
74HC162	16	1.29
74HC163	16	1.29
74HC164	14	1.29
74HC165	16	2.79
74HC166	16	2.95
74HC173	16	1.69
74HC174	16	.99
74HC175	16	.99
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.09
74HC195	16	1.09
74HC237	16	2.95
74HC240	20	1.95
74HC241	20	1.95
74HC242	14	1.95
74HC243	14	1.95
74HC244	20	1.95
74HC245	20	2.49
74HC251	16	.89

74HC253	16	.99
74HC257	16	.89
74HC259	16	1.49
74HC266	14	1.19
74HC273	20	2.89
74HC280	14	3.95
74HC299	20	4.95
74HC366	16	2.39
74HC367	16	2.39
74HC373	20	2.39
74HC374	20	2.39
74HC390	16	1.49
74HC393	14	1.49
74HC533	20	2.39
74HC534	20	2.39
74HC595	16	3.95
74HC688	20	3.19
74HC4002	14	.59
74HC4017	16	2.19
74HC4020	16	1.39
74HC4024	14	1.59
74HC4040	16	1.39
74HC4060	16	1.39
74HC4075	14	.59
74HC4078	14	.69
74HC4511	16	2.69
74HC4514	24	3.79
74HC4538	16	2.39
74HC4543	16	3.49

74HCU04 is unbuffered. All others are buffered.

74C—C/MOS

74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.69
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19

74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	1.19
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39

74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

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TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM320T-24		.89
LM322N	14	1.65
LM323K		5.95
LM324N	14	.59
LM329DZ		.65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.40
LM336Z		1.19
LM337MP		1.15
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM340T-24		.79
LM341P-5		.75
LM341P-12		.75
LM341P-15		.75

LM342P-5		.69
LM342P-12		.69
LM342P-15		.69
LF347N	14	1.49
LM348N	14	.99
LM350K		4.95
LF351N	8	.60
LF353N	8	1.00
LF355N	8	1.10
LF356N	8	1.10
LM358N	8	.69
LM359N	14	1.79
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380CN	8	1.10
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
LM387N	8	.89
LM389N	18	1.19
LM391N-80	16	1.19
LM392N	8	.69
LM398N	8	3.95
LM399H		5.00
TL494CN	16	3.95
TL496CP	8	1.19
NE531V	8	2.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
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LM556N	14	.69
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LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	3.95
NE571N	16	2.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.55
LM733N	14	1.00
LM739N	14	1.95

LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
MC1330AI	8	1.95
MC1349	8	1.79
MC1350	8	1.49
MC1358	14	1.95
LM1456V	8	1.95
LM1458CN	8	.59
LM1488N	14	.89
LM1489N	14	.89
LM1496N	14	1.95
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LM2902N	14	.89
LM2907N	14	2.49
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	2.95
LM3915N	18	2.95
LM3916N	18	2.95
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RC4195TK		4.49
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LM13600N	16	1.19
76477	28	3.95

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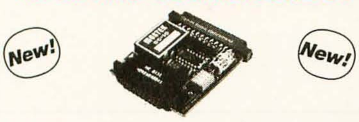
30003 1982 Nat. Linear Data Book (1952 pgs.) . **$11.95**

Commodore

RS232 ADAPTER FOR VIC-20 AND COMMODORE 64



The JE232CM allows connection of standard serial RS232 printers, modems, etc. to your VIC-20 and C-64. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.

· Plugs into User Port · Provides Standard RS232 signal levels · Uses 6 signals (Transmit, Receive, Clear to Send, Request to Send, Data Terminal Ready, Data Set Ready).

JE232CM $39.95

VOICE SYNTHESIZER FOR APPLE AND COMMODORE

• Over 250 word vocabulary-affixes allow the formation of more than 500 words • Built-in amplifier, speaker, volume control, and audio jack • Recreates a clear, natural male voice • Plug-in user ready with documentation and sample software • Case size: 7¼"L × 3¼"W × 1-3/8"H

APPLICATIONS:
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- Telecommunication
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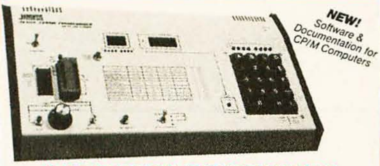
- Games

The JE520 VOICE SYNTHESIZER will plug right into your computer and allow you to enhance almost any application. Utilizing National Semiconductor's DIGITALKER™ Speech Processor IC (with four custom memory chips), the JE520 compresses natural speech into digital memory, including the original inflections and emphases. The result is an extremely clear, natural vocalization.

Part No.	Description	Price
JE520CM	For Commodore 64 & VIC-20	**$114.95**
JE520AP	For Apple II, II+, and *II*e	**$149.95**



JE664 EPROM PROGRAMMER

8K to 64K EPROMS — 24 & 28 Pin Packages

Completely Self-Contained — Requires No Additional Systems for Operation

· Programs and validates EPROMs · Checks for properly erased EPROMs · Emulates PROMs or EPROMs · RS232C Computer Interface for editing and program loading · Loads data into RAM by keyboard · Changes data in RAM by keyboard · Loads RAM from an EPROM · Compares EPROMs for content differences · Copies EPROMs · Power Input: 115VAC, 60Hz, less than 10W power consumption · Enclosure: Color-coordinated, light tan panels with molded end pieces in mocha brown · Size: 15⅝"L x 8¾"D x 3½"H · Weight: 5¾ lbs.

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K-Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM; (2) from an external computer via the optional JE665 RS232C BUS; (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMs can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

JE664-A EPROM Programmer. $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port. 9600 Baud, 8-bit word, odd parity and 2 stop bits.

FOR A LIMITED TIME A SAMPLE OF SOFTWARE WRITTEN IN BASIC FOR THE TRS-80* MODEL I, LEVEL II COMPUTER WILL ALSO BE PROVIDED.

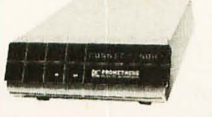
JE664-ARS EPROM Prog. w/JE665 Option. $1195.00
Assembled & Tested (Includes JM16A Module)

EPROM JUMPER MODULES – The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM Jumper Mod. No.	EPROM	Programming Voltage	EPROM MANUFACTURER	PRICE
JM08A	2708	25V	AMD, Motorola, Nat., Intel, TI.	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, Nat., NEC, TI, AMD, Hitachi, Mostek.	$14.95
JM16B	TMS2716 (3-V's)	-5V, +5V, +12V	Motorola, TI.	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI.	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel.	$14.95
JM64A	MCM68764, MCM68L764	21V	Motorola.	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI.	$14.95
JM64C	TMS2564	25V	TI.	$14.95

ProModem 1200

PROMETHEUS



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The ProModem™ is a Bell 212A (300/1200 baud) intelligent stand-alone modem · Full featured expandable modem · Standard features include Auto Answer and Auto Dial, Help Commands, Programmable Intelligent Dialing, Touch Tone™ and Pulse Dialing & More · Hayes command set compatible plus an additional extended command set · Shown w/alphanumeric display option.

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13⅛"L x 4¼"W x ¾"H

Mitsumi 54-Key Unencoded Matrix All-Purpose Keyboard

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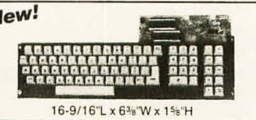
KB54. . . . . $14.95

New!



16-9/16"L x 6⅜"W x 1⅝"H

76-Key Serial ASCII Keyboard

· Simple serial interface · SPST mechanical switching · Operates in upper and lower case · Five user function keys: F1-F5 · Six finger edge card connection · Color (keys): tan · Weight: 2 lbs. · Data incl.

KB76. . . . . $29.95

Nationally Known Manufacturer!

21⅞"L x 9.8"W x 3⅛"H

106-KEY 8-BIT SERIAL ASCII KEYBOARD

· The terminals were designed to be daisy chained around a central host computer and used as individual work stations · Hall effect switching · numeric and cursor keypad · 10 user definable keys · 50" interface cable with 9-pin sub-miniature connector · 7 LED function displays · Security lock · N-key rollover · Automatic key repeat function · Color: (case): white w/black panel—(key caps): grey and blue · Weight: 6½ lbs. · Data included.

KB139 . . . . $59.95

New!

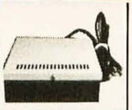
14½"L x 5½"W x 1½"H

68-Key Keyboard with Numeric Keypad for Apple II and II+

· Plugs directly into Apple II or II+ motherboard with 16-pin ribbon cable connector · 26 special functions · Color (keys): white/grey · Weight: 2 lbs.

KB-A68. . . . . $89.95

POWER SUPPLIES



TRANSACTION TECHNOLOGY, INC. 5VDC @ 1 AMP Regulated Power Supply

· Output: +5VDC @ 1.0 amp (also +30VDC regulated) · Input: 115VAC, 60 Hz · Two-tone (black/beige) self-enclosed case · 6 foot, 3-conductor black power cord · Size: 6½" L x 7" W x 2¼" H · Weight: 3 lbs.

PS51194 . . . . $14.95

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· Input: 105-125/210-250 VAC at 47-63 Hz · Line regulation: ±0.05% · Three mounting surfaces · Overvoltage protection · UL recognized · CSA certified

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· Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. · Fan volt./power supply select switches (115/230VAC) · Output: 5VDC @ 7.6 amp, 12VDC @ 1.5 amp · 8 foot black power cord · Size: 11½"L x 13¼"W x 3¾"H · Weight: 6 lbs.

PS94VOS. $39.95

KEPCO/TDK 4-OUTPUT SWITCHING POWER SUPPLY

· Ideal for disk drive needs of CRT terminals, microcomputers and video games · Input: 115/230VAC, 50/60Hz · Output: +5V @ 5 Amp, +12V @ 1.8 Amp, +12V @ 2 Amp, -12V @ 0.5 Amp · UL recognized · CSA certified · Size: 7⅜"L x 6-3/16"W x 1⅝"H · Weight: 2 lbs.

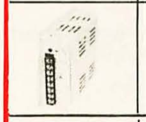
MRM 174KF. $59.95

New!

POWER PAC INC. REGULATED POWER SUPPLY

· Perfect for computer systems · Output: +5VDC @ 11 Amps, −5VDC @ 1 Amp, +12VDC @ 2 Amps, −12VDC @ 0.5 Amp and +24VDC @ 3 Amps · Overvoltage protection · Size: 12⅝"L x 6⅝"W x 4⅝"H · Weight: 17 lbs. · Spec incl.

PS2922. . . . . $69.95



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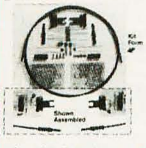

The EDU-LINK fiber optic system is a low-cost, TTL compatible data transmission system designed specifically as an educational tool for students and engineers working in many different industries. Includes: transmitter PCB, a receiver PCB, one meter of plastic optic fiber, and all the necessary electrical hardware · Complete step-by-step instructions, theory of operation, and tutorial information are included.

ELK-1. . . . . *ONLY* $19.95

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The ADD-514 Disk Drive uses Shugart SA390 mechanics–143K formatted storage · 35 tracks · Compatible with Apple Controller & ACC-1 Controller · The drive comes complete with connector and cable – just plug into your disk controller card · Size: 6"L x 3½"W x 8-9/16"D · Weight: 4½ lbs.

ADD-514 (Disk Drive). $195.95
ACC-1 (Controller Card). . . . . $ 59.95

Also Available...
JE864 (80 Col. + 64K RAM for *II*e). **$124.95**
JE614 (Numeric/Aux. Keypad for *II*e). **$89.95**
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INDUSTRIES ***Protect Yourself...***

DATASHIELD® Surge Protector

· Eliminates voltage spikes and EMI-RFI noise before it can damage your equipment or cause data loss · 6 month warranty · Power dissipation (100 microseconds): 1,000,000 watts · 6 sockets · 6 foot power cord · Normal line voltage indicator light · Brown out/black out reset switch · Weight: 2 lbs.

Model 100. $69.95

Protect Yourself...

DATASHIELD® Back-Up Power Source

Provides up to 30 minutes of continuous 120 VAC 60Hz power to your computer system (load dependent) when you have a black out or voltage sag · Output rating: 200 watts · Six month warranty · Weight: 24 lbs.

Model 200 (PC200). $349.95

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· Output rating: 300 watts

XT300. . . . . $489.95

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SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs) $49.95

TRS-80 MEMORY EXPANSION KIT

TRS-80 to 16K, 32K, or 48K

****Model 1 = From 4K to 16K Requires (1) One Kit**
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit

****Model 1 equipped with Expansion Board up to 48K Two Kits Required**
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns for Color & Model III **$12.95**
TRS-16K4 *250ns for Model I. **$10.95**

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kits comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 color computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

TRS-64K2. . . . . $44.95

UV-EPROM Eraser

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1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser . . . $79.95
UVS-11EL Replacement Bulb . . $16.95

Circle 196 on inquiry card.

```
                XOR     AH,AH            ;PARAMETER A THROUGH F
                MOV     SI,AX
                SUB     SI,41H
                SHL     SI,1
                ADD     SI,OFFSET A
VID70:          MOV     AH,AL            ;SAVE LAST LETTER
                INC     BX
                MOV     AL,[BX]
                CMP     AL,'?'
                JNE     VID80
                MOV     AL,'='
                MOV     [BX],AL
                CALL    HTOA             ;OUTPUT CURRENT VALUE
                INC     BX
                MOV     AL,'   '
                MOV     [BX],AL
                INC     BX
                MOV     AL,CR
                MOV     AH,'$'
                MOV     [BX],AX
                MOV     DX,OFFSET INBUFF+2
                MOV     CL,COSTR
                INT     BDOS
                JMP     VIDEO
VID80:          CMP     AL,'='
                JNE     VID90
                CALL    ATOH             ;INPUT HEX WORD
                JMP     VIDEO
VID90:          CMP     AH,AL
                JNE     VIDERR
                ADD     SI,16            ;AA THROUGH FF (OR BEYOND)
                JMPS    VID70
VIDERR:         PUSH    DS
                PUSH    CS
                POP     DS
                MOV     DX,OFFSET WMSG ;WHAT?
                MOV     CL,COSTR
                INT     BDOS
                POP     DS
                JMP     VIDEO
;---------------------- SUBROUTINES ----------------------
;
;
;
CAMERA:         XOR     AX,AX            ;DISPLAY SEQUENCE OF CAMERA ANGLES
                MOV     K,AX
                MOV     KK,AX
                MOV     KKK,AX
CAM10:          INC     K
                INC     KK
                INC     KKK
                TEST    W,-1
                JZ      CAM20
                MOV     ES,ENDSEG
                MOV     DI,ENDPOINT
                MOV     AX,D             ;WRITE POINT
                MOV     ES: [DI], AX
                MOV     AX,E
                MOV     ES:2[DI],AX
                MOV     AX,F
                MOV     ES:4[DI],AX
                MOV     AX,W
                MOV     ES:6[DI],AX
                XOR     AX,AX
                MOV     ES:14[DI],AX
CAM20:          MOV     AX,AA2           ;ADJUST CAMERA
                ADD     AA,AX
                MOV     AX,BBB
                ADD     BB,AX
                MOV     AX,CCC
                ADD     CC,AX
                MOV     AX,DDD
                ADD     DO,AX
```

(continued)

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All memories are good memories when they come from Cumana. Available for the Apple, Dragon, British Broadcasting Corporation and IBM personal computers, Cumana slimline disk drives are designed and manufactured to the highest standards to give outstanding performance and quiet operation.

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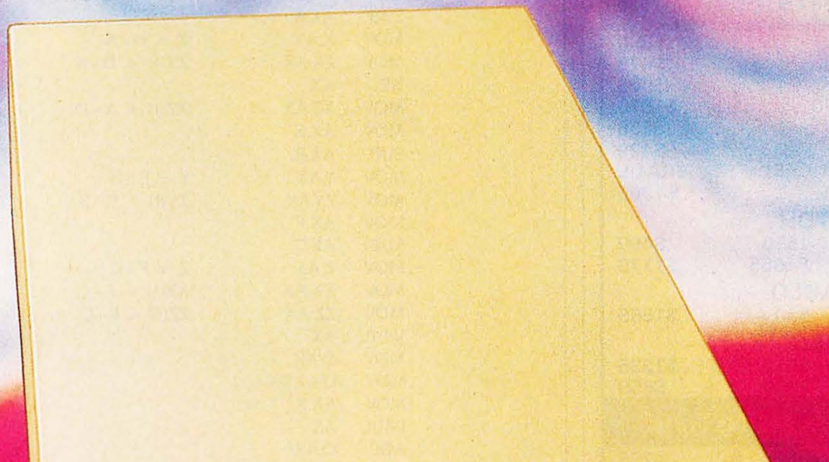

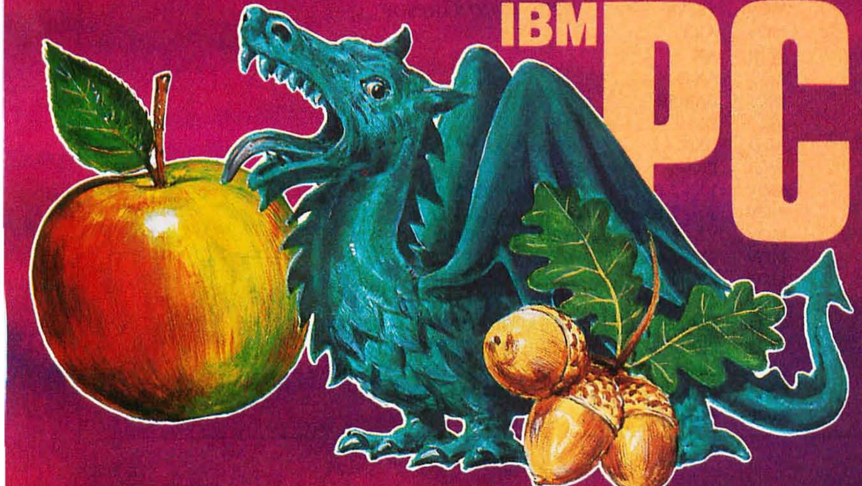

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```
          MOV   AX,EEE
          ADD   EE,AX
          MOV   AX,FFF
          ADD   FF,AX
          MOV   AX,AA
          ADD   A,AX
          MOV   AX,BB
          ADD   B,AX
          MOV   AX,CC
          ADD   C,AX
          MOV   AX,DO
          ADD   D,AX
          MOV   AX,EE
          ADD   E,AX
          MOV   AX,FF
          ADD   F,AX
          MOV   AX,D            ;COMPUTE OTM
          SUB   AX,A
          MOV   X,AX            ;X = D-A
          MOV   ZX,AX           ;ZX(1) = D-A
          NEG   AX
          MOV   XZ,AX           ;XZ(1) = A-D
          MOV   AX,E
          SUB   AX,B
          MOV   Y,AX            ;Y = E-B
          MOV   ZY,AX           ;ZY(1) = E-B
          MOV   AX,F
          SUB   AX,C
          MOV   Z,AX            ;Z = F-C
          MOV   XX,AX           ;XX(1) = F-C
          MOV   ZZ,AX           ;ZZ(1) = F-C
          IMUL  AX
          MOV   Q,AX
          MOV   Q+2,DX
          MOV   AX,X
          IMUL  AX
          ADC   Q,AX
          JNC   CAM40
          INC   DX
CAM40:    ADD   Q+2,DX          ;Q = X*X+Z*Z
          MOV   AX,Q
          MOV   DX,Q+2
          CALL  ISQRT
          MOV   XX+2,BX         ;XX(2) = SQRT Q
          MOV   XZ+2,BX         ;XZ(2) = SQRT Q
          MOV   YY,BX           ;YY(1) = SQRT Q
          MOV   AX,XZ
          IMUL  Y
          IDIV  BX
          MOV   YX,AX           ;YX(1) = Y*XZ(1)/SQRT Q
          MOV   AX,XX
          NEG   AX
          IMUL  Y
          IDIV  BX
          MOV   YZ,AX           ;YZ(1) = -Y*XX(1)/SQRT Q
          MOV   AX,Y
          IMUL  AX
          ADC   AX,Q
          JNC   CAM50
          INC   DX
CAM50:    ADD   DX,Q+2          ;Q = X*X+Y*Y+Z*Z
          CALL  ISQRT
          MOV   YX+2,BX         ;YX(2) = SQRT Q
          MOV   YY+2,BX         ;YY(2) = SQRT Q
          MOV   YZ+2,BX         ;YZ(2) = SQRT Q
          MOV   ZX+2,BX         ;ZX(2) = SQRT Q
          MOV   ZY+2,BX         ;ZY(2) = SQRT Q
          MOV   ZZ+2,BX         ;ZZ(2) = SQRT Q
          CALL  CLEAR           ;CLEAR INACTIVE DISPLAY AREA
          CALL  PERSP           ;GENERATE PERSPECTIVE
          CALL  SWAP            ;SWAP ACTIVE DISPLAY AREAS
          CALL  PRINT           ;PRINT PARAMETERS
          MOV   AX,RRR
```

(continued)

Circle 295 on inquiry card. →

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Circle 21 on inquiry card.

```
                CMP     AX,KKK
                JNE     CAM60
                NEG     BBB
                NEG     CCC
                NEG     EEE
                NEG     FFF
                XOR     AX,AX
                MOV     KKK,AX
                JMPS    CAM70
CAM60:          SHR     AX,1            ;ADJUST AA2 AND DDD AT HALF PERIOD
                CMP     AX,KKK
                JNE     CAM70
                NEG     AA2
                NEG     DDD
CAM70:          MOV     AX,RR
                CMP     AX,KK
                JNE     CAM80
                NEG     AA
                NEG     BB
                NEG     CC
                NEG     DO
                NEG     EE
                NEG     FF
                XOR     AX,AX
                MOV     KK,AX
CAM80:          MOV     AX,R
                CMP     AX,K
                JBE     CAM90
                JMP     CAM10           ;NEXT PERSPECTIVE
CAM90:          RET
;------------------------------------------------------------------
PERSP:          MOV     ES,MEMBOT       ;GENERATE PERSPECTIVE OF 3D POINTS
                MOV     DI,OFFSET POINTS
PER10:          MOV     AX,ES:6[DI]     ;NEXT PIXEL
                TEST    AX,-1           ;ALL DONE?
                JNZ     PER20           ;NOT YET
                MOV     ENDSEG,ES
                MOV     ENDPOINT,DI
                RET
PER20:          MOV     AX,ES:[DI]      ;COMPUTE PERSPECTIVE OF NEXT POINT
                SUB     AX,A
                MOV     X,AX            ;X = ES:[DI]-A
                MOV     AX,ES:2[DI]
                SUB     AX,B
                MOV     Y,AX            ;Y = ES:2[DI]-B
                MOV     AX,ES:4[DI]
                SUB     AX,C
                MOV     Z,AX            ;Z = ES:4[DI]-C
PER25:          IMUL    AX
                MOV     Q,AX
                MOV     Q+2,DX
                MOV     AX,Y
                IMUL    AX
                ADC     Q,AX
                JNC     PER30
                INC     DX
PER30:          ADD     Q+2,DX
                MOV     AX,X
                IMUL    AX
                ADC     Q,AX
                JNC     PER40
                INC     DX
PER40:          ADD     Q+2,DX          ;Q = X*X+Y*Y+Z*Z
                MOV     AX,Q
                MOV     DX,Q+2
                CALL    ISQRT           ;BX = SQRT Q
                MOV     AX,I
                MOV     II,AX
                MOV     AX,J
                MOV     JJ,AX
PER50:          MOV     AX,X
                IMUL    XX
```

(continued)

Circle 236 on inquiry card.

Multi-function RS-232 Transfer Switches

MFJ-1240 $79.95 *Choice of 8 models*

Multi-function RS-232 transfer switches let you switch your computer among printers, modems, terminals, any RS-232 peripherals; monitor data/line failure, protect data lines from surges, and use as null modem for less cost than a switch alone. **Switches 10 lines** (2, 3, 4, 5, 6, 8, 11, 15, 17, 20). LED data/line indicators monitor lines 2, 3, 4, 5, 6, 8, 20. Metal oxide varistors protect data lines 2, 3 from voltage spikes and surges. Push button reverses transmit-receive lines (2, 3). PC board eliminates wiring, crosstalk, line interference. Connects any one input to any one output.

Model	Price	In	Out	Model	Price	In	Out
MFJ-1240	$79.95	1	2	MFJ-1244	$139.95	3	3
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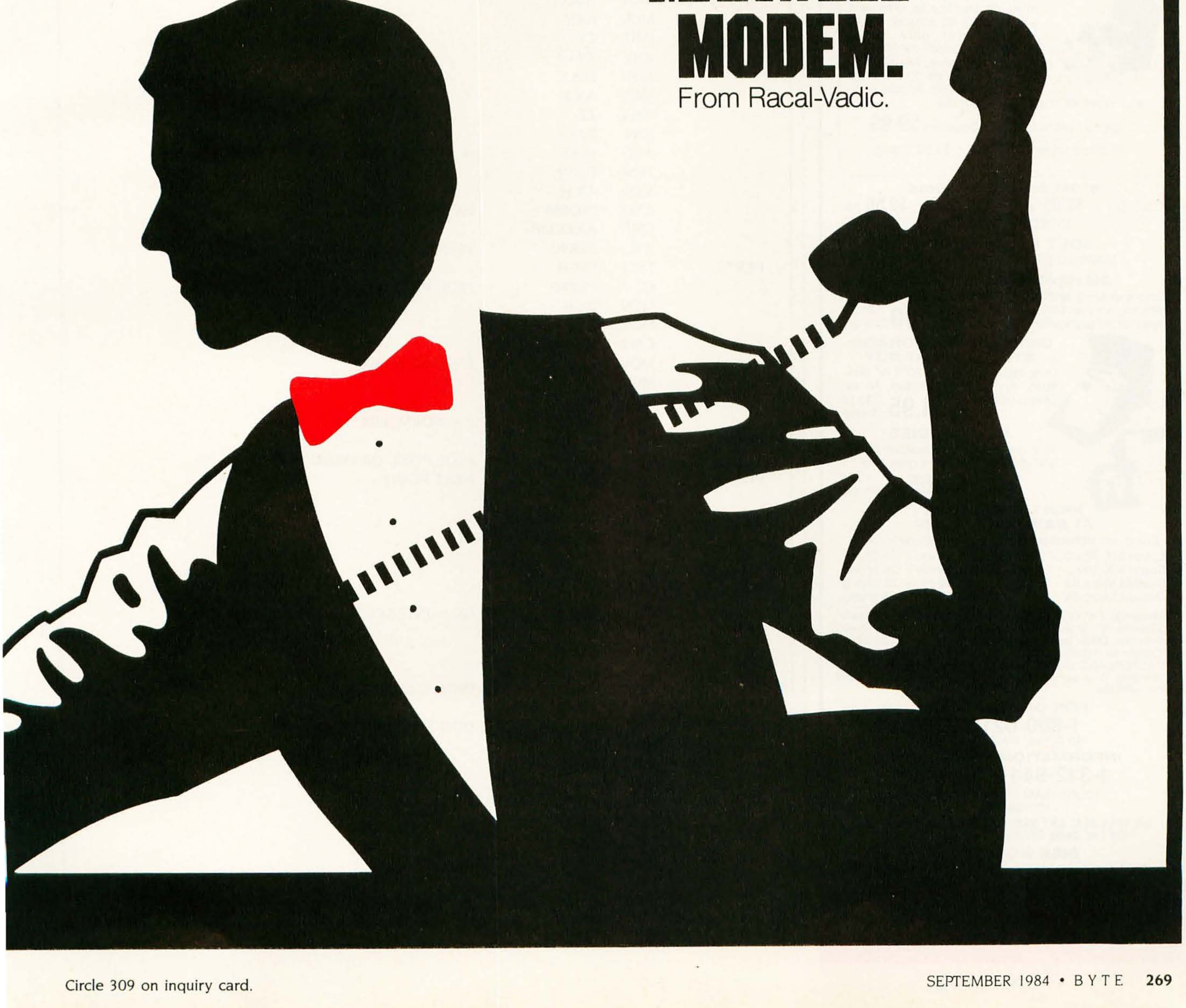

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```
                IDIV    XX+2
                MOV     I,AX
                MOV     AX,Z
                IMUL    XZ
                IDIV    XZ+2
                ADD     I,AX             ;I = XX*X+XZ*Z
                MOV     AX,X
                IMUL    YX
                IDIV    YX+2
                MOV     J,AX
                MOV     AX,Y
                IMUL    YY
                IDIV    YY+2
                ADD     J,AX
                MOV     AX,Z
                IMUL    YZ
                IDIV    YZ+2
                ADD     J,AX             ;J = YX*X+YY*Y+YZ*Z
                TEST    P,0EH
                JNZ     PER75            ;ISOMETRIC PERSPECTIVE
PER60:          MOV     AX,X             ;COMPUTE H
                IMUL    ZX
                IDIV    ZX+2
                MOV     H,AX
                MOV     AX,Y
                IMUL    ZY
                IDIV    ZY+2
                ADD     H,AX
                MOV     AX,Z
                IMUL    ZZ
                IDIV    ZZ+2
                ADD     H,AX             ;H = ZX*X+ZY*Y+ZZ*Z
                TEST    P,20H
                MOV     AX,H
                CALL    INORM            ;BX STILL = SQRT Q
                CMP     AX,CCLIP
                JLE     PER90            ;POINT NOT IN FRONT OF CAMERA
PER70:          TEST    P,0FH
                JZ      PER80            ;TRUE PERSPECTIVE
                MOV     BX,H
                MOV     AX,I
                CALL    INORM
                MOV     I,AX             ;I = NORM*I/BX
                MOV     AX,J
                CALL    INORM
                MOV     J,AX             ;J = NORM*J/BX
PER80:
                CALL    PLOT             ;PLOT PIXEL OR DRAW VECTOR
PER90:          ADD     DI,8             ;NEXT POINT
                JNZ     PER95
                MOV     AX,ES
                ADD     AX,1000H
                MOV     ES,AX
PER95:          JMP     PER10
;—
ISQRT:          MOV     BX,DX            ;BX = INTEGER SQUARE ROOT OF DXAX
                SHL     BX,1
                OR      BL,AH
                OR      BL,AL
                ADD     BX,DX            ;INITIAL GUESS
                JG      ISQ10
                INC     BX               ;DON'T RETURN ZERO
                JG      ISQ10
                MOV     BX,7FFFH
                RET
ISQ10:          PUSH    AX
                PUSH    DX
                DIV     BX
                SUB     AX,BX
                CMP     AX,1
                JBE     ISQ90
                CMP     AX,-1
```

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```
          JAE    ISQ90           ;0.1 OR -1 IS CLOSE ENOUGH
          SAR    AX,1
          ADD    BX,AX           ;NEXT APPROXIMATION
          POP    DX
          POP    AX
          JMPS   ISQ10
ISQ90:    POP    DX
          POP    AX
          RET
;—
INORM:    MOV    CX,NORM         ;AX = NORM*AX/BX
          IMUL   CX
          IDIV   BX
          RET
;—
SETFCB:   PUSH   BX              ;MOVE FILENAME AT BX+1 INTO FCB
          PUSH   CS
          POP    ES
          MOV    DI,OFFSET FCB
          XOR    BX,BX
          MOV    ES:[DI],BL      ;DEFAULT DRIVE
          MOV    ES:FEX[DI],BL   ;CURRENT EXTENT
          MOV    AL,' '
          MOV    CX,11
SETF10:   INC    BX              ;BLANK NAME
          MOV    ES:[DI+BX],AL
          LOOP   SETF10
          POP    BX
          INC    BX
          MOV    AX,[BX]
          CMP    AH,':'
          JNE    SETF20
          SUB    AL,40H
          MOV    ES:[DI],AL      ;DRIVE DESIGNATION
          INC    BX
          INC    BX
SETF20:   INC    DI
          MOV    AL,[BX]
          CMP    AL,'.'
          JE     SETF40
          CMP    AL,0
          JE     SETF60
          MOV    ES:[DI],AL
          INC    BX
          JMPS   SETF20
SETF40:   INC    BX              ;FILENAME EXTENSION
          MOV    CX,3
          MOV    DI,OFFSET FCB+9
SETF50:   MOV    AL,[BX]
          CMP    AL,0
          JE     SETF60
          MOV    ES:[DI],AL
          INC    BX
          INC    DI
          LOOP   SETF50
SETF60:   RET
;—
INFILE:   PUSH   DX              ;SEGMENT OF MEMORY AREA
          PUSH   BX              ;OFFSET OF MEMORY AREA
          MOV    DX,OFFSET FCB
          MOV    CL,FOPEN
          INT    BDOS
          POP    BX
          POP    DX
          CMP    AL,-1
          JNE    INF40
          MOV    DX,OFFSET FNFMSG ;FILE NOT ON DISK
          MOV    CL,COSTR
          INT    BDOS
          RET
INF40:    PUSH   DX
          PUSH   BX
```

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Circle 241 on inquiry card.

```
            MOV     CL,FDMAS
            INT     BDOS            ;SET DMA SEGMENT
            POP     DX
INF50:      PUSH    DX
            MOV     CL,FDMAO
            INT     BDOS            ;SET DMA OFFSET
            MOV     DX,OFFSET FCB
            MOV     CL,FREAD
            INT     BDOS
            TEST    AL,-1
            JNZ     INF90           ;END OF FILE
            POP     DX
            ADD     DX,80H          ;NEXT RECORD
            JNZ     INF50
            MOV     BX,DX
            POP     DX
            ADD     DX,1000H
            JMPS    INF40
INF90:      ADD     SP,4
            RET
;—
OUTFILE:    PUSH    DX              ;SEGMENT OF MEMORY AREA
            PUSH    BX              ;OFFSET OF MEMORY AREA
            MOV     DX,OFFSET FCB
            MOV     CL,FDELETE
            INT     BDOS
            MOV     DX,OFFSET FCB
            MOV     CL,FMAKE
            INT     BDOS
            POP     BX
            POP     DX
            CMP     AL,-1
            JNE     OUTF40
            MOV     DX,OFFSET NRODMSG ;NO ROOM IN DIRECTORY
            MOV     CL,COSTR
            INT     BDOS
            RET
OUTF40:     PUSH    DX
            PUSH    BX
            MOV     CL,FDMAS
            INT     BDOS            ;SET DMA SEGMENT
            POP     DX
OUTF50:     PUSH    DX
            MOV     CL,FDMAO
            INT     BDOS            ;SET DMA OFFSET
            MOV     DX,OFFSET FCB
            MOV     CL,FWRITE
            INT     BDOS
            TEST    AL,-1
            JZ      OUTF70          ;RECORD ON DISK
            MOV     DX,OFFSET NRODMSG
            MOV     CL,COSTR
            INT     BDOS
            ADD     SP,4
            JMPS    OUTF90
OUTF70:     POP     DX
            ADD     DX,80H          ;NEXT RECORD
            JZ      OUTF80
            CMP     DX,ENDPOINT
            JBE     OUTF50
OUTF80:     MOV     BX,DX
            POP     DX
            CMP     BX,0
            JE      OUTF85
            CMP     DX,ENDSEG
            JAE     OUTF90
OUTF85:     ADD     DX,1000H
            JMPS    OUTF40
OUTF90:     MOV     DX,OFFSET FCB
            MOV     CL,FCLOSE
            INT     BDOS            ;CLOSE FILE
            RET
```

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MATHEMATICAL SOLUTION

A 3-D artificial environment (3DAE), or database, must contain three numbers for each point it represents. These numbers, or coordinates, specify the location of the point within the environment. There may be other numbers associated with the point that indicate its color, or whether it and other points form a line segment, etc. For now, consider only three coordinates. Write them as an ordered triple (x,y,z).

Suppose that your camera or eye is situated at the origin (0,0,0) of your 3DAE and that it is oriented so you are looking down one of the three major axes. Designate this as the z-axis and straight ahead as the positive z direction. Straight up is the positive y-axis, and the horizontal direction to the right is the positive x-axis. This yields a 2-D perspective that is oriented in the x,y plane. Your line of sight to a point in the 3DAE is just the vector, or ray, (x,y,z). Now, if you place the imaginary flat screen one unit away from the camera on the positive z-axis, the point of intersection with the vector (x,y,z) will be the point on the vector with its third coordinate equal to 1, $(x/z,y/z,1)$. Likewise, in true perspective the intersection of this vector with the unit sphere about your eye will be that point $(x/q,y/q,z/q)$ such that the distance to the origin is 1, i.e., q = square root $(x^2+y^2+z^2)$.

Given that the camera is at an arbitrary position and oriented in an arbitrary direction, how do you get it into the standard position and orientation? The origin can be moved to the camera position by an operation called transformation. During a transformation you add the same three constants to every point in the 3DAE, which keeps the relative positions of the points and the camera unchanged. These three constants should be $(-a,-b,\ -c)$, where (a,b,c) is the position of your camera. A point that was at (x,y,z) would be at $(x-a,\ y-b,z-c)$ if the camera were at (0,0,0).

Once the camera is in standard position (0,0,0), its orientation can be adjusted via rotation. Any rotation about the origin can be broken down into no more than three rotations, one around each of the major axes. A rotation

(continued)

```
;—
ATOH:       XOR   DX,DX            ;CONVERT ASCII AT BX+1 TO HEX AT SI
            MOV   CL,4
ATOH10:     INC   BX
            MOV   AL,[BX]
            SUB   AL,30H
            JL    ATOH30
            CMP   AL,0AH
            JB    ATOH20
            SUB   AL,7
            CMP   AL,0FH
            JA    ATOH30
ATOH20:     SHL   DX,CL
            OR    DL,AL
            JMPS  ATOH10
ATOH30:     MOV   [SI],DX
            RET
;—
HTOA:       MOV   DX,[SI]          ;CONVERT HEX AT SI TO ASCII AT BX+1
            MOV   CX,4
HTOA10:     INC   BX
            ROL   DX,1
            ROL   DX,1
            ROL   DX,1
            ROL   DX,1
            MOV   AL,0FH
            AND   AL,DL
            ADD   AL,30H
            CMP   AL,'9'
            JBE   HTOA20
            ADD   AL,7
HTOA20:     MOV   [BX],AL
            LOOP  HTOA10
            RET
;—
PRINT:      MOV   BX,OFFSET OUTBUFF ;PRINT PARAMETERS
            MOV   SI,OFFSET A
            MOV   AX,'=A'
PRI20:      PUSH  AX
            MOV   [BX],AX
            INC   BX
            CALL  HTOA
            INC   SI
            INC   SI
            ADD   BX,4
            POP   AX
            INC   AL
            CMP   AL,'F'
            JBE   PRI20
            MOV   SI,OFFSET K
            MOV   AL,'R'
            MOV   [BX],AX
            INC   BX
            CALL  HTOA
            ADD   BX,4
            MOV   SI,OFFSET P
            MOV   AX,'=P'
            MOV   [BX],AX
            INC   BX
            CALL  HTOA
            ADD   BX,4
            MOV   SI,OFFSET W
            MOV   AX,'=W'
            MOV   [BX],AX
            INC   BX
            CALL  HTOA
            INC   BX
            MOV   AL,CR
            MOV   AH,'$'
            MOV   [BX],AX
            MOV   DX,OFFSET OUTBUFF
            MOV   CL,COSTR
```

(continued)

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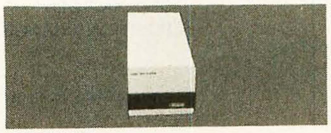

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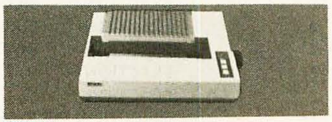

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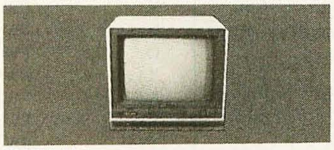

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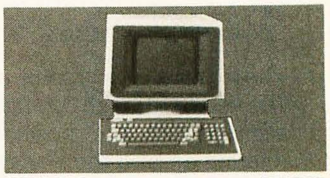

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around a major axis is essentially a 2-D rotation; the coordinate along that major axis does not change. For example, the entire 3DAE can be rotated 30 degrees about the *y*-axis by the following:

$$x' = x\text{Cos}30 - z\text{Sin}30$$
$$y' = Y$$
$$z' = x\text{Sin}30 + z\text{Cos}30$$

where (x,y,z) is any point in the 3DAE. The vector through 0 in figure 2 can be aligned with the positive *z*-axis by rotating around the *x*- and *y*-axes. You can apply the yaw rotation that will take the point at 0 to 1 to each point in the 3DAE; then you can apply the pitch rotation that will take the point at 1 to 3. Or, you can apply a pitch rotation first, taking the route passing through 2. The noncommutativity of matrix multiplication assures that the two cases require different amounts of yaw and pitch rotation.

If you let (a,b,c) equal the position of the camera, (Y,P,R) equal yaw, pitch, and roll, and (x,y,z) equal an arbitrary point in the environment, you can obtain (i,j)—a position of a point in perspective—by the matrix multiplication in figure 3.

Since the three 3-by-3 matrices in figure 3 must be applied to each point (x,y,z) in the 3DAE, you will get a faster algorithm if you first multiply them into a single 3-by-3 orientation transformation matrix (OTM). You supply the values Y, P, and R (from which the OTM is constructed), as well as *a*, *b*, and *c* (the camera position), in real time. These values can be absolute or relative to your current position and orientation. If you save that current position (a,b,c), then, given a change (aa,bb,cc) in (a,b,c), you can use $(a+aa,b+bb,c+cc)$ as the next absolute camera position. Similarly, if you save the current OTM, given a relative change in yaw, pitch, and roll (YY,PP,RR) you can update the current OTM by multiplying it on the right side of the equation by the OTM you could have generated if (YY,PP,RR) had been absolute.

Should a relative change in position (aa,bb,cc) also change the current (Y,P,R)? What would a change in yaw (YY,0,0) mean if you were looking straight up? It would be easier if you did not have to worry about yaw, pitch, and roll. After

(continued)

```
                INT     BDOS
                RET
;*****************************************************************************
;                 IF ROMED, THE FOLLOWING 3 WORDS AS WELL AS THE FCB
;                           MUST BE MOVED INTO A DATA SEGMENT
;
MEMBOT          RW      1               ;BOTTOM OF AVAILABLE MEMORY
ENDPOINT        RW      1               ;OFFSET OF LAST POINT IN 3DAE
ENDSEG          RW      1               ;SEGMENT OF LAST POINT IN 3DAE
GETBOT          DB      18,0,0,0,0      ;GET BOTTOM OF MEMORY BIOS CALL
WMSG            DB      'WHAT?',CR,'$'
FNFMSG          DB      'FILE NOT FOUND',CR,'$'
NRODMSG         DB      'NO ROOM ON DISK',CR,'$'
                DSEG                    ;THE FOLLOWING DATA IS ASSIGNED
                ORG     0               ;TO THE BOTTOM OF AVAILABLE MEMORY
;
INBUFF          RB      80H             ;CONSOLE INPUT BUFFER
OUTBUFF         RB      80H             ;CONSOLE OUTPUT BUFFER
;-----------------------------------------------------------------------------
                ORG     100H
A               RW      1               ;CAMERA POSITION
B               RW      1
C               RW      1
D               RW      1               ;CAMERA ORIENTATION
E               RW      1
F               RW      1
R               RW      1               ;REPEAT FACTOR
K               RW      1               ;STEP FACTOR
AA              RW      1               ;POSITION CHANGE
BB              RW      1
CC              RW      1
DO              RW      1               ;ORIENTATION CHANGE
EE              RW      1
FF              RW      1
RR              RW      1               ;PERIOD FACTOR
KK              RW      1
AA2             RW      1               ;SECOND DERIVATIVES
BBB             RW      1
CCC             RW      1
DDD             RW      1
EEE             RW      1
FFF             RW      1
RRR             RW      1               ;2ND DERIVATIVE PERIOD
KKK             RW      1
W               RW      1               ;WRITE MODE (PIXEL CODE)
X               RW      1               ;WORKING STORAGE
Y               RW      1
Z               RW      1
V               RW      1
P               RW      1               ;TYPE OF PERSPECTIVE
Q               RW      2               ;LONG INTEGER, Q+2 = HIGH-ORDER BITS
XX              RW      2               ;FRACTION, XX+2 = DENOMINATOR
XZ              RW      2               ;FRACTION
YX              RW      2               ;FRACTION     THESE 8 FRACTIONS ARE THE
YY              RW      2               ;FRACTION     NONZERO ENTRIES OF THE 3x3
YZ              RW      2               ;FRACTION     ORIENTATION TRANSFORMATION
ZX              RW      2               ;FRACTION     MATRIX (OTM)
ZY              RW      2               ;FRACTION
ZZ              RW      2               ;FRACTION
H               RW      1               ;DIRECTION OF SIGHT
I               RW      1               ;(I,J) = CURRENT DISPLAY POINT DISPLACEMENT
J               RW      1               ;           FROM CENTER OF SCREEN
II              RW      1               ;LAST I
JJ              RW      1               ;LAST J
;-----------------------------------------------------------------------------
                ORG     200H
POINTS:                                 ;3DAE STARTS HERE (8 BYTES/POINT)
;*****************************************************************************
INCLUDE GRAPHIC.DOC
;
;
;       The Graphics subroutines: INIT, CLEAR, SWAP, and PLOT must conform
;to the following specifications:
```

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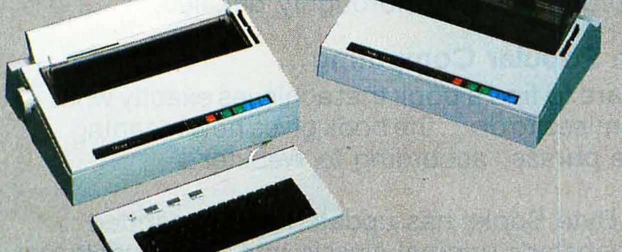
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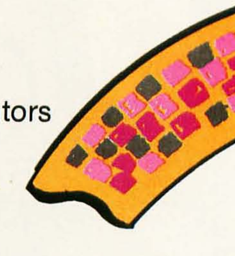

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all, when you walk about, you do perhaps consider changes such as $(aa,0,cc)$, but never the corresponding (YY,PP,RR) required to keep your eyes on a given fixed object. You must already provide the coordinates for the camera. It might be more natural for you to also provide the coordinates of the focal point. This has another advantage in that the point of focus can be left fixed. You can then adjust the camera's position without having to update yaw, pitch, and roll each time to keep the focal point in the middle of the screen. See if you can reproduce the OTM in terms of camera position (a,b,c) and a focal point (d,e,f) only.

By adopting the notation $|x,y,z|$ = square root $(x^2+y^2+z^2)$, you can rewrite the yaw and pitch components of the OTM as shown in figure 4. Note that the yaw matrix on the right is undefined if $d=a$ and $f=c$. This is the case where the camera is pointed straight up or straight down. If you applied a pitch matrix first, it would then mean that looking to the left or the right would be undefined. A matrix for roll has not been included because there is no representation of roll in this two-point system. The point you are viewing remains the same. If you consistently apply the yaw matrix before the pitch matrix and avoid looking straight up or down, up will always be defined and unalterable. Thus, roll can be applied later, if desired, in terms of whatever parameters are convenient.

```
;
;      INIT takes no arguments and should prepare the display device to
;draw. INIT might contain a complete initialization of the device or might
;suppose this to have already been done. INIT should also initialize any
;local variables of the Graphics subroutines. INIT must preserve the DS
;register.
;
;      CLEAR takes no arguments. If only one display area is used, CLEAR
;has no restrictions except that it return with the display device set in
;the same mode (ready to draw) as when called. If more than one display area
;is used, CLEAR may share data and flags with SWAP and PLOT. CLEAR must
;preserve the DS register.
;
;      SWAP is a switch PERSP throws whenever a new picture is ready. If
;two display areas are used, SWAP should wait until the next vertical retrace
;and then program the display device to begin refreshing the screen from the
;other display area. It must then set a flag directing PLOT to use the in-
;active display area in subsequent calls from PERSP. SWAP must preserve the
;DS register.
;
;      PLOT takes as arguments DS:I, DS:J, and ES:-2[DI] where DS is the
;segment of the bottom of available memory and ES is the segment of the
;current 3DAE point being processed by PERSP. I and J are the horizontal
;and vertical screen coordinates of the current 3DAE point in perspective.
;These coordinates may need to be scaled, inverted, or added to a constant
;before they can be plotted on any given display device. DS:II and DS:JJ,
;the previous screen coordinates, are also available. The pixel codes
;of the current and previous 3DAE points are accessible at ES:6[DI]
;and ES:-2[DI], respectively. PLOT must preserve the registers DS, ES, and DI.
;
;Any variable storage needed by PLOT, CLEAR, or SWAP is available at DS:180.
;
;      The conventions regarding the high digits of the perspective
;parameter P are as follows:
;      If the second digit from the right is odd (i.e., P AND 10H NOT 0),
;then xy clipping is overridden. Clipping may be permanently disabled by
;reassembling with CLIPNAB EQU FALSE.
;      If the third digit from the right is odd (i.e., P AND 100H NOT 0),
;then full screen clear is invoked. This bit will come on automatically,
;in GDCPLOT, if the number of OUT instructions needed to draw the picture
;exceeds 16K. Full screen clear will result in no clearing if reassembled
;with SCLEAR EQU FALSE.

INCLUDE GRAPHIC.A86       ;SUBSTITUTE GDCPLOT, IBMPLOT, OR WRITE YOUR OWN
;
            CSEG   $
INIT:       RET
CLEAR:      RET
SWAP:       RET
PLOT:       RET
;----------------------------------------------------------------------
            CSEG   $               ;RESERVED CODE
            ORG    0FFFH
            DB     0
;----------------------------------------------------------------------
            END
END OF ASSEMBLY.  NUMBER OF ERRORS:  0.  USE FACTOR:  4%
```

MICROCOMPUTER SOLUTION

Having reduced the OTM to a two-point form, the only mathematical operation needed (other than addition, subtraction, multiplication, and division) is the square-root function. It can be computed in terms of the other four operations by successive approximation.

First, however, what sort of numbers have you assumed for your coordinates? The way a microprocessor performs arithmetic on real numbers is called floating-point arithmetic. It is quicker, even with a high-speed 8087-type floating-point coprocessor, if you have to perform arithmetic only on integers. Since you are attempting to represent the real world with the coordinate system, it might at first seem useless to limit yourself to 16-bit integers. However, if you designate a unit to be the smallest distance you will want to distinguish, your representable universe will consist of $65,536^3$ cubic units. Thus, if you wanted to distinguish down to a millimeter in height, breadth, or width, you could represent a cube measuring 65 meters on a side. You could represent a small town (a cubic mile) with a resolution of 1 inch.

Therefore, each point in the 3DAE will consist of four 16-bit words of memory. The first three words are the three absolute coordinates (x,y,z). The fourth word is interpreted as four nybbles (hexadecimal digits). The leftmost nybble (high-order digit) indicates the dimension of the graphic primitive. A 0 is a single dot, a 1 is a line segment, and so on. The three other nybbles indicate the colors and the patterns of the colors to be used. Hexadecimal F (or all 1s) means a solid line of a given color, for

(continued)

MicroAge franchisees Ernie Venta and Elayne Kalman shown with an IBM Personal Computer.

example. The 3DAE is loaded from disk (or built) at the bottom of available memory and can grow upward through multiple segments (8192 points, 64K bytes).

The 3DVS program is a loop within a loop. The larger loop, CAMERA, executes each time the camera's position or orientation changes. CAMERA may loop from 1 to 65,535 times, depending on the repeat parameter, R. The smaller loop, PERSP, must be as fast as possible because it executes once for each point in the environment. PERSP in turn calls the GDC routine PLOT, which draws the points, line segments, etc., on the screen. In true perspective you can compute the length of the vector from the camera to the point before you apply the OTM. In drafting perspective you must rotate the *z* component as specified by the OTM before you can determine the intersection of the line of sight and the flat screen. The *z* component (H) is useful for other purposes as well. It lets you measure whether an object is in front of you ($H>0$) or behind you ($H<0$). In either type of perspective, the equations involved yield an alternate set of solutions. A point behind you (i.e., that the camera is pointed away from) will also have a line of sight if you do not exclude it, intersecting the flat screen or the front of the sphere. Luckily, H (or H normalized with I and J) can be used to exclude such points via an operation called circle clipping.

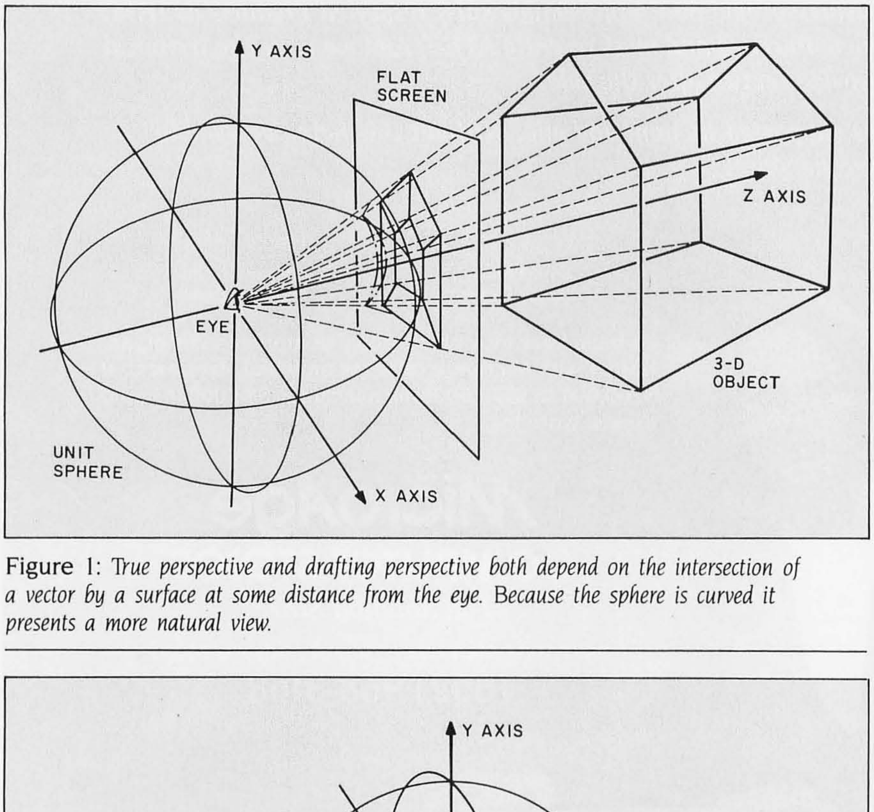

Figure 1: *True perspective and drafting perspective both depend on the intersection of a vector by a surface at some distance from the eye. Because the sphere is curved it presents a more natural view.*

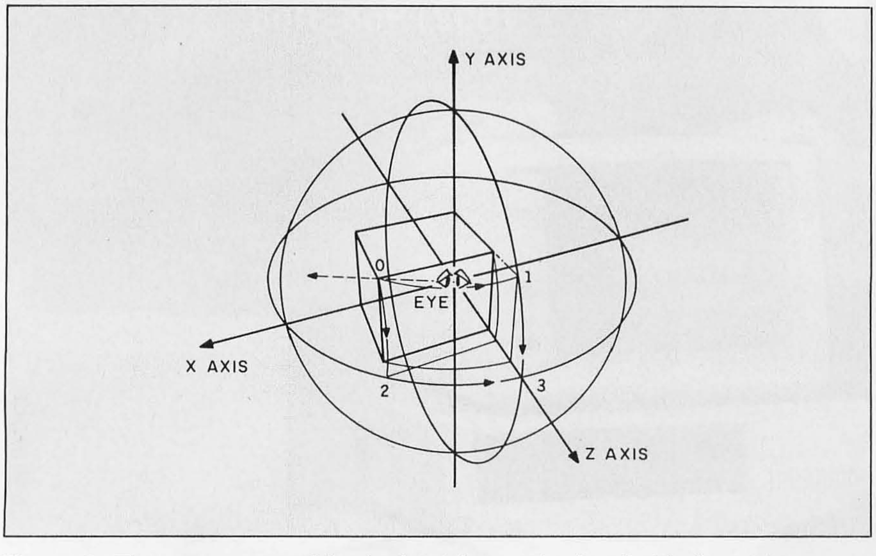

Figure 2: *The vector represented by the dotted line can be aligned with the positive z-axis in either of two ways. The noncommutativity of matrix multiplication assures that the two cases require different amounts of yaw and pitch rotation.*

The overhead of storing your 3DAE and the amount of time needed for PERSP to process it can be significantly reduced by using higher-dimensional graphic primitives. A one-dimensional line segment can be encoded as a pair of zero-dimensional graphic primitives, i.e., its endpoints. A polyhedron face can be encoded as a set of line segments, etc.

Using higher-dimensional graphic primitives with true perspective has some interesting consequences. A property of true perspective is that straight lines in the environment do not necessarily project into straight lines on the screen unless they cross the center. Projecting two endpoints and having the GDC connect them on the screen will always result in a straight line. This discrepancy can be minimized by using only short vectors. Long lines can be broken into connected short segments (using the repeat and the double-letter parameters) almost as easily as drawing the original line. Such a line will be indistinguishable from a single long line in drafting perspective but will follow the curves that true perspective implies. This will also guard against the entire line disappearing when one of its endpoints is circle clipped.

Two problems that are trivial when you're dealing with zero-dimensional graphic primitives become difficult in a higher-dimensional environment; they are clipping and hidden line (point, plane) removal. The target version of the 3DVS solves clipping for lines (the only higher-dimensional primitive supported). NEC ignores the second problem by contending that points and lines cannot hide anything. Adding such features presupposes that area filling could also be added, and the current hardware is too slow for that.

(continued)

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$$\begin{pmatrix} \\ j \\ k \end{pmatrix} = \begin{pmatrix} \mathrm{CosR} & -i\mathrm{SinR} & 0 \\ \mathrm{SinR} & \mathrm{CosR} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \mathrm{CosP} & -\mathrm{SinP} \\ 0 & \mathrm{SinP} & \mathrm{CosP} \end{pmatrix} \begin{pmatrix} \mathrm{CosY} & 0 & -\mathrm{SinY} \\ 0 & 1 & 0 \\ \mathrm{SinY} & 0 & \mathrm{CosY} \end{pmatrix} \begin{pmatrix} x-a \\ y-b \\ z-c \end{pmatrix}$$

followed by normalization and dropping the third coordinate:

$$\begin{pmatrix} i \\ j \end{pmatrix} = \begin{pmatrix} 1/q & 0 & 0 \\ 0 & 1/q & 0 \end{pmatrix} \begin{pmatrix} i \\ j \\ k \end{pmatrix}$$

where q = length of vector (i, j, k)
=square root $(i^2 + j^2 + k^2)$
=square root $((x-a)^2 + (y-b)^2 + (z-c)^5)$
or q =k for drafting perspective

Figure 3: *Since the three 3-by-3 matrices must be applied to each point* (x,y,z) *in the* 3DAE, *a faster algorithm will result if they are first multiplied together into a single 3-by-3 orientation transformation matrix.*

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \dfrac{|d-a,f-c|}{|d-a,e-b,f-c|} & \dfrac{b-e}{|d-a,e-b,f-c|} \\ 0 & \dfrac{e-b}{|d-a,e-b,f-c|} & \dfrac{|d-a,f-c|}{|d-a,e-b,f-c|} \end{pmatrix} \begin{pmatrix} \dfrac{f-c}{|d-a,f-c|} & 0 & \dfrac{a-d}{|d-a,f-c|} \\ 0 & 1 & 0 \\ \dfrac{d-a}{|d-a,f-c|} & 0 & \dfrac{f-c}{|d-a,f-c|} \end{pmatrix}$$

Figure 4: *Note that the yaw matrix on the right is undefined if* d=a *and* f=c. *This is the case where the camera is pointed straight up or down.*

To produce smooth motion, at whatever speed, you need to use more than one screen refresh area. That way, the most recent picture can remain on the screen while the next is being prepared. You can then switch the screen to the new refresh area during a vertical retrace period.

Another hardware-related feature that you might at first overlook turns out to be significant: clearing the display areas. Even though you need to clear only the area you are about to write into, this amounts to a hardware-bound task taking almost a second. For a reasonably small collection of points and line segments, it turns out to be quicker to "undraw" only the points last drawn. This has the desirable side advantage that the background can be painted with any colors not already present in the 3DAE and they will stay. Or, you can obtain a trace of the object by painting it with the same colors. (A positive trace can be obtained by assembling VIDEO with SCLEAR=FALSE and then invoking full-screen CLEAR.)

If you are using two refresh areas, you must "undraw" the picture you drew the time before last—not the one you just drew. In either case, you must save the points as you draw them. You could save just the previous OTM and recompute the previous perspective that, although light on storage requirements, is not fast enough. You could save the I,J screen coordinates produced by PERSP. Note that you must save two copies at once because you will reuse the oldest perspective first. Alternatively, you could (and NEC does) save the individual instructions that are issued to the GDC to draw the picture—called OUT instructions. The 3DVS sets aside one segment of program RAM (64K bytes) to store two sets of 16K-byte OUT instructions. When this maximum is exceeded, the 3DVS will automatically shift into the more conventional full-screen (display area) ERASE. If another 128K-byte bank of program RAM is added to the system, the 3DAE can grow to considerable complexity, and the speed of the 3DVS will slow proportionally. If you are willing to give up real-time control, the individual frames can be recorded on videotape and played back as fast as desired.

Many features such as screen erase and vector preserving *x-y* clipping, which contribute the largest part of the code to the driver, may eventually be provided by the hardware. A couple of tricks that NEC purposely did not support are worth mentioning. You can test changes in the single-letter parameters by calling for (G)—a nonexistent file. This will produce a single updated perspective without starting the programmed sequence. The whole 3DAE can be purged without disturbing the run-time parameters by setting DDD...(17)..D=0. The isometric scaling factor may be accessed at AA . . . (7) . . A. The hexadecimal I/O may be unnatural to some operators, but it was left that way because NEC felt that it made things easier for most people. The company also thought it lent itself well to joystick operations. The way it now stands, you might find 3DVS to be excellent practice in hexadecimal arithmetic.

VIDEO, CAMERA, and perhaps PERSP could be written more concisely (and portably) in C. This first version of the 3DVS was designed to be as fast as possible so that it would compare well with other varieties of graphics packages. There is an older C version of CAMERA and PERSP, but it does not include VIDEO. There is also a GSXPLOT that replaces the complexities of GDCPLOT with Digital Research's standard AGSX calls. Both of these varieties are slower than the older custom-built versions, but the standardization of design has so many agreeable attributes that we can expect to see more of it in 3DVS version 2. There is also a multitasking version of the 3DVS that allows PERSP and CLEAR or PLOT to run concurrently. ■

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FROM PIXELS TO MICRODOTS

BY JANE MORRILL TAZELAAR

The emergence of an exciting new technology

FOR SOME TIME, a movement in microcomputer graphics has been growing—a movement to increase display resolution and color availability and still maintain a price in the microcomputer range. The problems are threefold and interrelated: monitor resolution, memory, and money.

Let's take these one at a time. If you significantly raise the resolution of the monitor, you have either a monochrome monitor or a far more expensive display device than microcomputer owners usually can afford. For example, the Hercules Graphics Card (Hercules Computer Technology, 160 Beechnut Drive, Hercules, CA 94547) lets you generate 720- by 348-pixel, high-resolution, bit-mapped graphics on an IBM PC monochrome display with 64K bytes for $499. Several other graphics cards let you do about the same thing.

Photo 1: *The* VideoShow 150 *unit shown with its hand-held remote control and the* PictureIt Series 100 *software disk.*

If you want graphics in 16 colors along with better-than-average high resolution, you can choose from the following: Cono-Color 40 (Conographic Corp., 2268 Golden Circle, Newport Beach, CA 92660), which has a resolution of 512 by 512 pixels with 128K bytes for $995; IDEAgraph (IDEAssociates Inc., 7 Oak Park Drive, Bedford, MA 01730), which has a resolution of 512 by 512 pixels with 128K bytes, also for $995; Intelligent Hi-Res Graphics (Frontier Technologies Corp., POB 11238, Milwaukee, WI 53211), which has a resolution of 1024 by 1024 pixels and 512K bytes for $1985 (including required modules for 16 colors); Artist I (Control Systems Inc., 2855 Anthony Lane, Minneapolis, MN 55418) with a resolution of 1024 by 1024 pixels and 512K bytes for $2195; and other available packages.

If you want more than 16 colors, one version of IDEAgraph has the same 512- by 512-pixel resolution with 256 colors and 256K bytes for $1895. As resolution and color availability—and thus memory requirements—increase, so does the price.

There is a fairly simple rule when it comes to memory: The more colors and

(continued)

Jane Morrill Tazelaar is a technical editor at BYTE. *She can be reached at* POB 372, *Hancock,* NH 03449.

the higher resolution you want, the more memory you must have. First, you need 1 byte for each pixel on the screen (for 512 by 512, that's 256K bytes) and then you must account for the colors—but with bits, not bytes. To represent 16 colors, you need 4 bits or half a byte (one-half of that 256K bytes is 128K bytes—the total memory needed for 512 by 512 pixels in 16 colors). IDEAgraph's 256-color version requires a full 8 bits for color determination and thus needs a total of 256K bytes of memory.

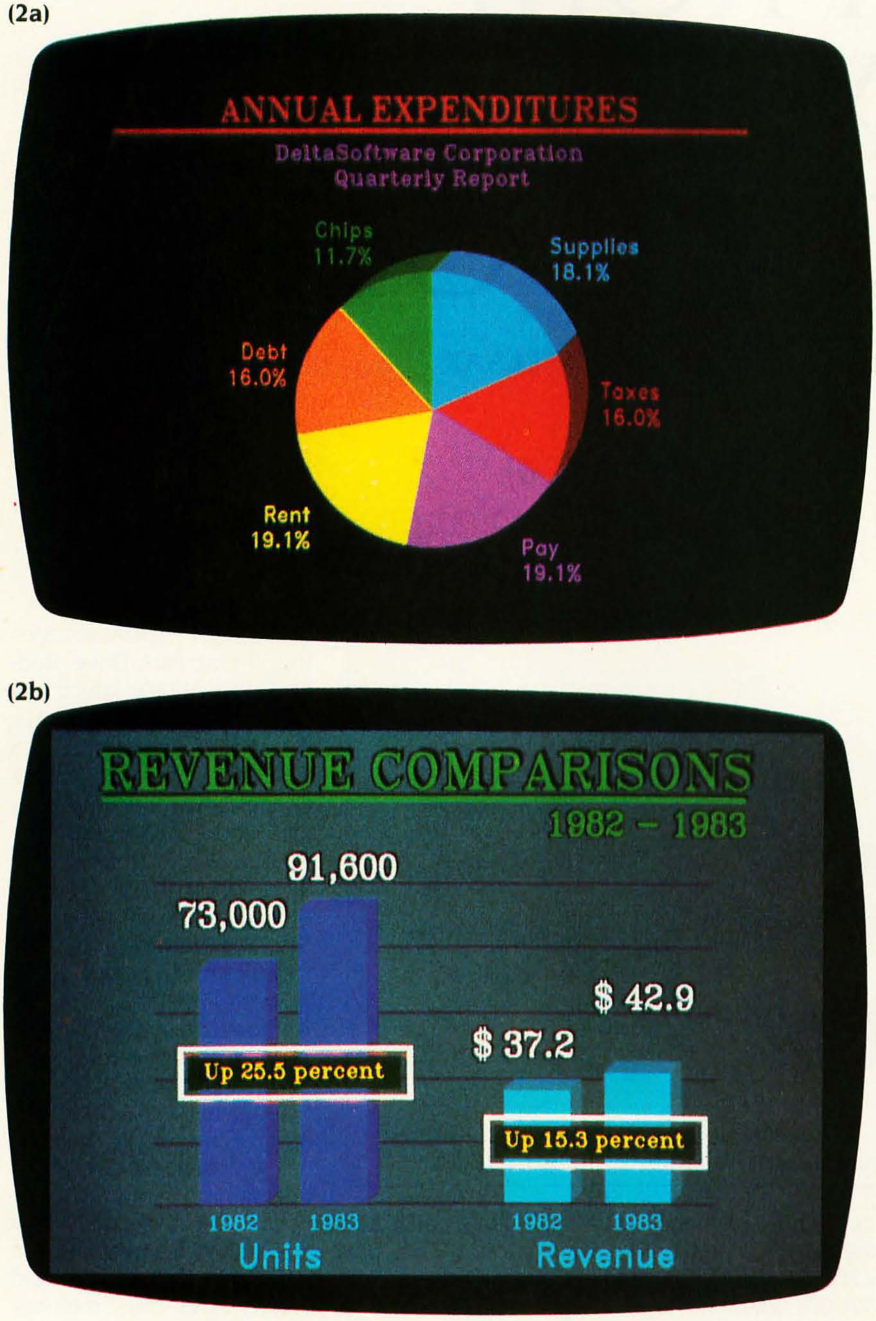

Photo 2: A *pie chart (a) and a bar chart (b) produced by the* PictureIt *software on the VideoShow unit. These photos were taken of the displays seen on a normal* IBM PC *color monitor.*

This is the current microcomputer graphics world. But things are changing; some of these restrictions are going away; the rules aren't the rules anymore. I recently attended the National Computer Graphics Association (NCGA) conference in Anaheim, California. NCGA is not really a conference for microcomputer users. But I saw a demonstration there that I think is one of the most exciting developments in microcomputer graphics in a long time.

The company is General Parametrics (1505 Solano Avenue, Berkeley, CA 94707); the specific product is called PictureIt. At first glance, this appears to be just another business-graphics package. But look below the surface. General Parametrics is using a brand-new technology. Instead of resolving pictures by the pixel, they are resolved *by the microdot*. With a standard IBM PC color monitor, a small unit called VideoShow (see photo 1) that is no larger than a normal floppy-disk drive, and the PictureIt program disk, this package displays graphics in much higher resolution than either the hardware or the IBM graphics card (320 by 200 pixels) is capable of. Sound impossible? I agree, but I have seen it. To look at the graphics (see photo 2), you would think that the monitor resolution was 2000 by 484 pixels, but it's not. The monitor hasn't changed.

This magic is the result of a process called MacroVision in which hardware and software combine to render the individual microdots within the pixel programmatically controllable. This level of control gives you 1000 (that's right, one thousand) available colors. The VideoShow unit contains 256K bytes of RAM, and the PictureIt software requires only 128K bytes of RAM on the IBM PC. According to the formula above, 2000- by 484-pixel resolution with 1000 colors would require 1182K bytes—more than a megabyte.

To quote General Parametrics' president, Herb Baskin, "MacroVision replaces pixels—the clusters of dots that form traditional video images—with variable-sized groups of dots that can be positioned to a much higher degree of accuracy. Eliminating the pixel triad restriction in this manner increases the possible shades and textures on VideoShow's displays to 1000—as opposed to a maximum of 16 in systems

(continued)

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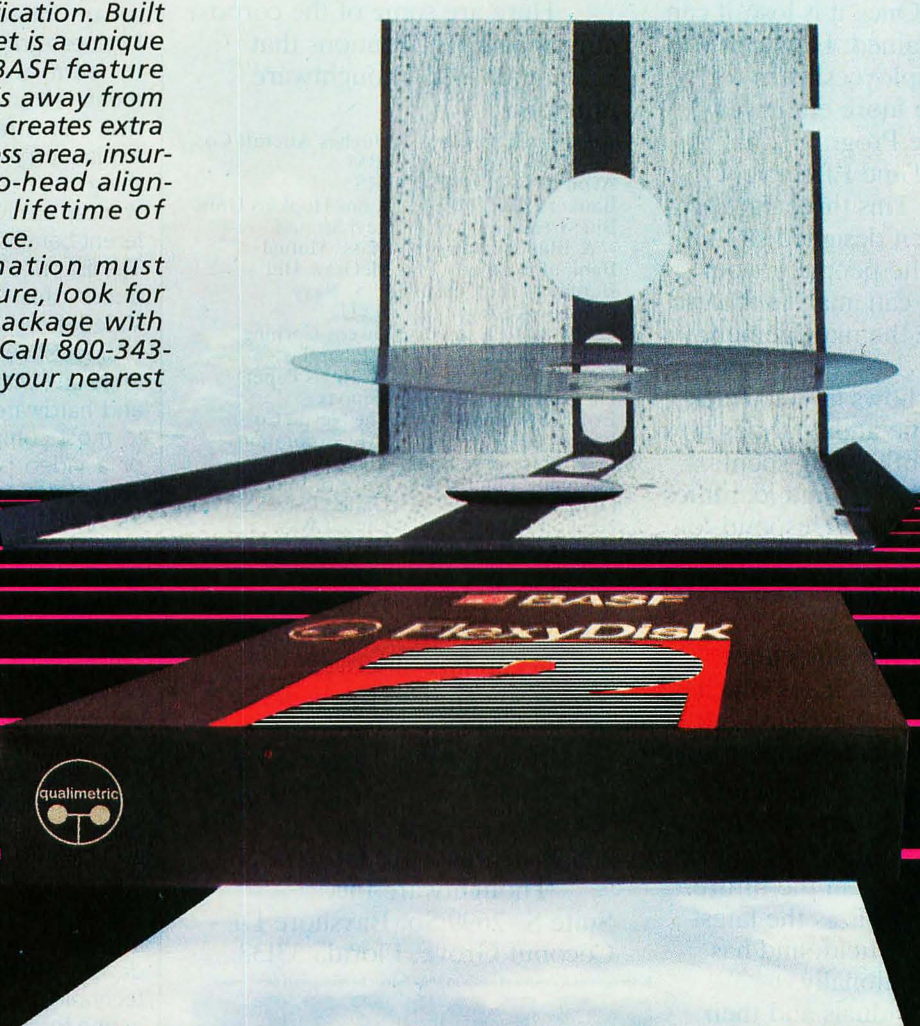

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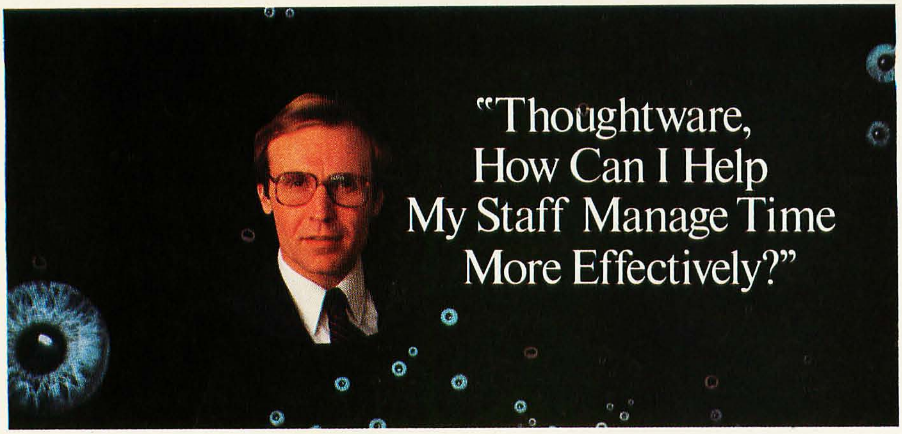

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> *General Parametrics' new technology might revolutionize microcomputer graphics.*

using pixel triads—and results in much higher image quality. A Horizontal Position Accuracy (HPA) of 1/2000 . . . assures sharp edge definition and slide-like clarity."

The PictureIt Series 100 software itself is an impressive and professional business-graphics package that is easy to learn and use through a simple menu-driven process. The documentation is straightforward and self-explanatory—a thin manual with everything you need right at your fingertips. You can easily access and modify 25 different bar charts, graphs, pie charts, etc. The list price of this software (which produces this resolution only on the VideoShow unit) is $595.

VideoShow 150 is a 16-pound portable unit with a single floppy-disk drive and hardware support. It can connect to most computer monitors, a TV set, or a video projector. VideoShow 150 contains an Intel 8086 microprocessor. Its hand-held remote control device controls your presentation, moving forward and backward and jumping around from slide to slide, building slide overlays dynamically during your presentation, creating and moving a pointer, and more. It's as easy to use as you can imagine. The list price for this unit is $3295.

General Parametrics has produced a fine business presentation graphics package that should be well received. Its price might seem high to individual microcomputer owners, but for presentation graphics of this quality it is very low. As more and more programs are developed to use this exciting new technology, it should become available in one form or another at a lower price.

General Parametrics has introduced a new technology that might revolutionize microcomputer graphics. Goodbye, pixels! Hello, microdots! ■

I would like to thank Leslie Frohoff of Hardcopy magazine for notifying me of this exciting development. Cooperation among journalists is a valuable commodity.

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- **The decision process was accelerated:** 64% of study participants said they made their business decisions *immediately after the visual presentation.* When overheads were not used, the control group said they delayed decision-making until *some time after the group discussion following the presentation.*
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REVIEW FEEDBACK **355**

LAST MONTH ANOTHER SECTION of this magazine ran a series of articles on Modula-2, a new language that is becoming increasingly popular. Some mention was made of the Lilith, a powerful Modula-2-based machine with an operating system that is derived from the same source as the operating system for the Apple Lisa and Macintosh. This month we start off with a review of a commercial version of the Lilith made available by Modula Computer Systems. Paul Sand takes a close look at the very impressive capabilities of this machine.

Somewhat later in this issue we again return to the Modula-2 world, this time as it relates to the powerful Sage 68000-based machine. Ed Joyce sets up Volition's version of Modula-2 on the Sage's p-System and examines the power of this combination.

For those of us who are more at home in the MS-DOS world, we have a review of a rather recent clone of the IBM Personal Computer (PC). Jeffrey Mazur takes a look at the Leading Edge Personal Computer. It seems as if it's not enough to be just a clone of the IBM PC anymore. You have to have something extra besides a lower price. The Leading Edge machine features good compatibility with the IBM and also has a faster processor. Jeff examines the compatibility and speed of this new system.

For the CP/M world also, new machines must boast something extra to be heard over the crowd. The Morrow MD-11 comes complete with a pile of software and a 10-megabyte hard disk—all for a very reasonable price. John Heilborn examines whether this is as good a bargain as it sounds.

Finally, we present a bit of a change. Most of our reviews are concerned with finished products (although a few products do not seem as finished as we might like). This month we are going to try something new and present a review of some specialized chips—voice-synthesis chips to be precise. George Smith takes a look at linear predictive coding chips, a version of which was used in Texas Instruments' Speak and Spell. Besides being Hollywood's preferred device for extraterrestrial communication, these chips have some interesting features.

—*Rich Malloy, Product-Review Editor*

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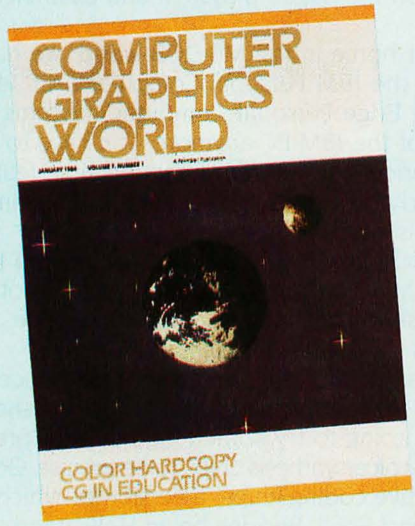

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COMPUTER GRAPHICS WORLD

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REVIEWER'S NOTEBOOK

IN THE PAST YEAR, I've set up about 30 computers. Fortunately, almost all of them were very easy to get running. And last month, when a friend received a computer from a company down in Boca Raton, I offered to spend what I thought would be five minutes to set it up.

The IBM PC is, of course, a good, useful computer, but I had forgotten how difficult it is to get working. It has been on the market for about three years. You'd think that in all that time they would at least come up with an easy-to-read instruction manual, or maybe even an easy way to remove the cover.

A smaller and somewhat friendlier machine just arrived here from Epson. The folks who brought us the first briefcase computer—the Epson HX-20—have come out with their second briefcase unit—the Geneva PX-8.

This new machine, which sells for $950, offers several improvements over the previous briefcase machine. It features an 80-character by 8-line LCD (liquid-crystal display)—an 800 percent increase in size over the HX-20—a Z80-compatible microprocessor, the CP/M operating system (in ROM chips), 64K bytes of volatile memory, a 15-hour nicad battery, a microcassette data recorder, and an interesting bundle of software in interchangeable ROM chips. This software consists of four 32K-byte chips: one each for Microsoft BASIC, a word processor (WordStar), a combination of a spreadsheet and a scheduler program, and a group of CP/M utilities that includes communication software. These chips are set up as "ROM drives" from which programs can be called into system memory. The problem is that only two of these chips can be inserted into the machine at one time.

Options include a flat, half-inch thick, 60K-byte "RAM disk" that can be added to the bottom of the machine ($320) or a direct-connect modem of the same shape ($120). Also, a battery-powered, 3½-inch floppy-disk drive is available (380K bytes per disk) but costs $595.

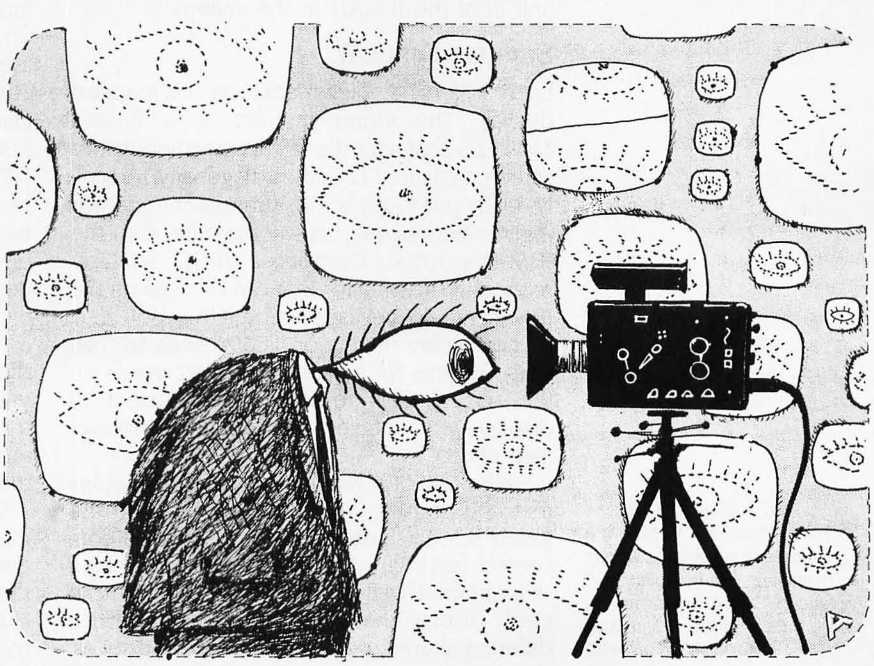
The only thing the system seems to lack is a parallel printer port and an option for a full-size display. The PX-8's display is not as fast as the TRS-80 Model 100's, but it is twice as large. This machine may prove to be a useful second machine for CP/M system owners.

And speaking of the Epson HX-20, Skiwriter, the word processor that came with the diminutive machine, is now available for other computers, specifically, the Commodore 64 and the IBM PCjr. (An Apple II version is supposedly on the way.) This new version is called Skiwriter II and is being published by Prentice-Hall. The cartridge version for the Commodore 64 is inexpensive ($50) and is faster than many programs running on the IBM PC. The PCjr version is a little more expensive ($70) but is even faster. In fact, I saw the PCjr version running on the Compaq and I was amazed at its speed.

Skiwriter II has some other amazing properties, including a telecommunications program that can be accessed at any time while you are using the word processor. All three versions (Commodore, IBM, and Apple II) were written in assembly code by one person (Ken Skier). And the entire package fits in 16K bytes of code.

In response to our video issue (July), we received an interesting product called the Telecomp 1000 from Valiant International Multi-Media Corporation (195 Bonhomme St., Hackensack, NJ 07602; (201) 487-6340). This relatively inexpensive product (approximately $320) allows you to insert signals from a video camera into your computer display. It attaches between your computer and your composite monitor and allows you to project the output from a video camera onto any part of your computer display. You could probably, for example, set up a promotional display with which a person could watch some videotaped material in one part of the screen while reading your promotional text on another part.

—*Rich Malloy, Product-Review Editor*



SYSTEM REVIEW

The Lilith Personal Computer

High performance results from a computer architecture built around Modula-2

BY PAUL A. SAND

A Lilith computer has four hardware components: the system unit, the video display, the keyboard, and the mouse (see photo 1). The system unit is a nearly cubical box that houses the processor, memory, peripheral interfaces, and disk drives. A black plastic panel on the front, above the disk drives, slides up to reveal a card cage with room for 14 boards. The version of Lilith reviewed in this article has eight boards installed (see photo 2). From top to bottom, these boards are a 256K-byte memory board; the display processor, which creates the video signals necessary to drive Lilith's display; the instruction fetch unit; another 256K-byte memory board; the processor data port, which exchanges data between memory and the processor and also contains a real-time clock, interfaces for the keyboard and mouse, and a general-purpose RS-232C serial interface; the micro-control unit, the board that executes the microcoded instructions; the arithmetic/logic unit, which contains the bit-slice processor, barrel shifter, and fast evaluation stack; and the disk interface board, which controls Lilith's disk drives. Two fans on the left side of the system unit cool the boards in the system.

SCREEN DISPLAY

Lilith offers a high-resolution bit-mapped display. The video monitor is a Roland MB-122G character display; its green-phosphor screen measures 12 inches diagonally. (Actually, Lilith produces a TTL (transistor-transistor logic) video signal that's compatible with the IBM Personal Computer (PC), so any monochrome monitor that can be used on the IBM can also be used with Lilith.)

The display resolution is 594 lines by 768 dots per line, for a total of 456,192 pixels on the screen. This resolution is sufficient to display very detailed pictures and drawings (see photo 3).

Lilith's use of a bit-mapped display enables text and graphics to be freely mixed on the video screen; indeed, as far as Lilith is concerned, text characters are simply another kind of graphics. This flexibility means that Lilith can easily display characters in a variety of fonts: different shapes, sizes, thicknesses, and styles. The software provided with the Lilith includes approximately 50 different character fonts stored on the hard disk; a typical font description takes up approximately 2000 to 3000 bytes. Utility programs exist to inspect these fonts, change them, and even create new ones. Library modules provide the programmer with the ability to use a variety of fonts in his own programs.

Another feature the bit-mapped display supports is *windowing*: the ability to simulate several independent displays on a single screen. As with fonts, Lilith uses windows to great advantage in many of its own programs. Library modules that are included with the Lilith computer system enable the programmer to make use of windowing as well.

KEYBOARD AND MOUSE

In contrast to Lilith's other components, the keyboard is completely conventional. It is a full ASCII (American National Standard Code for Information Interchange) keyboard with a numeric keypad similar to that found on a Digital Equipment Corporation (DEC) VT-100 terminal (see photo 4). There are four cursor-movement keys and four special function keys on the keyboard, but as far as I can tell, they aren't used by any of the provided software. They aren't really needed, of course, because Lilith's mouse takes over many, if not all, of the functions traditionally provided by such keys.

The three-button mouse (see photo 5) is hemispherical and about the size of half a softball. To use the mouse, you place your hand on top of the mouse and push it around your desktop; the buttons are operated by the middle three fingers of that hand. The mouse rolls on a spherical ball that detects the two-dimensional motions of the mouse. This enables the user to manipulate the mouse as a pointing device: moving the mouse causes analogous movements of a "mouse cursor" on the screen.

Much of the software provided with Lilith makes heavy use of the mouse, although the details differ from program to program. As with the other hardware components, you must include the provided library modules to use the mouse in your programs.

Paul A. Sand (10 Hemlock Forest, Dover, NH 03820) is a freelance writer and computer programmer. He is the author of Advanced Pascal Programming Techniques, *published by* Osborne/McGraw-Hill.

MASS STORAGE

Lilith's primary mass-storage device is a 15-megabyte Winchester hard disk, partitioned into a 10-megabyte region and a 5-megabyte region. When Lilith is turned on, the user may choose to boot up either the 10-megabyte or 5-megabyte partition. There are utility programs to transfer files between the partitions.

To provide backup for the hard disk, Lilith uses a 5¼-inch floppy-disk drive to which files can be read or written by utility programs. Interestingly, the floppy-disk format is Apple II compatible at the track/sector level. Although the floppy disks formatted by Lilith do not have a directory structure readable by Apple DOS 3.3, Apple Pascal, or CP/M, any of these operating systems can read and write the disks on a track-and-sector basis. (I was able to write a small program to transfer files from a Lilith disk to a normal Apple CP/M disk without much trouble.)

MEDOS-2

The philosophy of the Modula-2 language greatly influenced the design of Medos-2, Lilith's operating system. Essentially, the operating system is a collection of Modula-2 modules that perform hardware-dependent tasks such as drawing on the display screen or reading a file from disk. The Modula-2 language, of course, makes no distinction between operating-system modules and any other modules. Accessing operating-system functions within a Modula-2 program is thereby extremely simple: the program needs only to use Modula-2 **FROM . . . IMPORT** statements naming the relevant items from one or more operating-system modules and call the desired procedures. What could be easier?

An additional benefit of this organization is that only the operating system modules used by the current program need actually be present in memory. The module that enables communication over the RS-232C interface, for example, is brought into memory only if the program to be executed needs that function and therefore imports that module. The only elements of the operating system that are in memory all the time are ones necessary to allocate memory, load programs from disk, and perform simple keyboard input and screen output.

Obviously, this organization makes it easy to add functions to the operating system; all that's involved is writing a new module. And because source code is provided for nearly all the library modules Lilith uses, a careful program-

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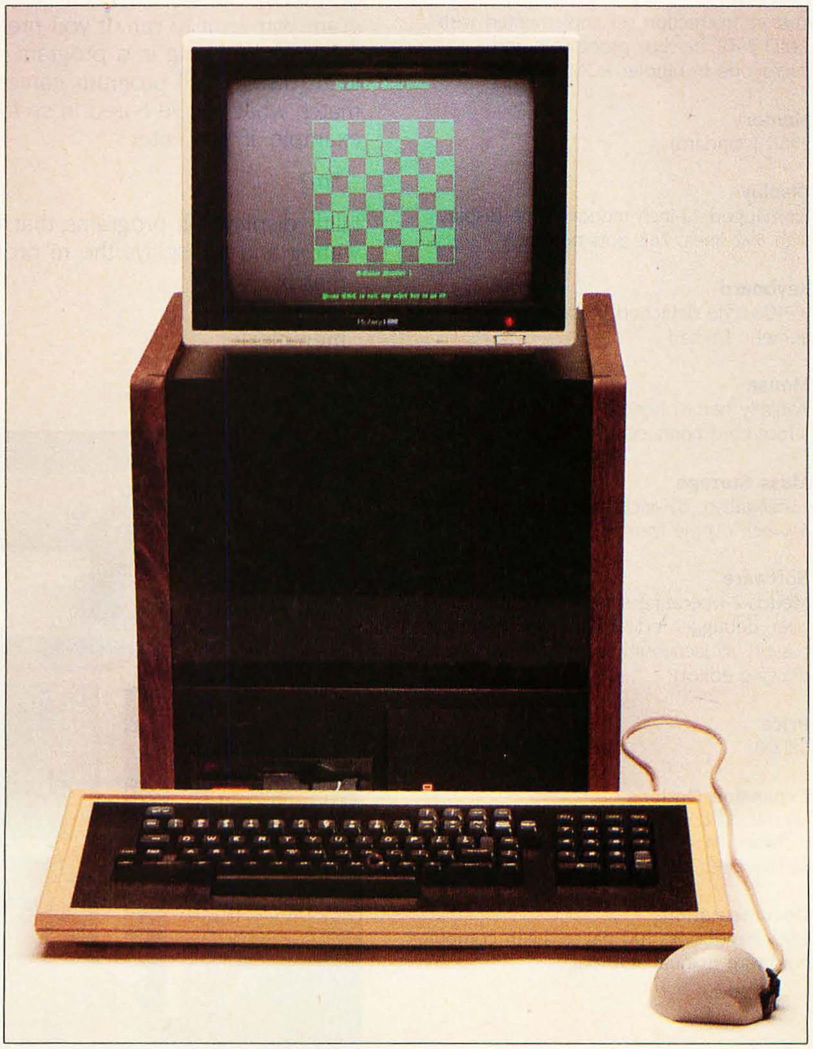

Photo 1: *The Lilith Personal Computer. The four components of a Lilith are the system unit, the video display, the keyboard, and the mouse.*

AT A GLANCE

Name
Lilith 2.1

Manufacturer
Modula Computer Systems
950 North University Ave.
Provo, Utah 84604
(801) 377-3598

Size
System unit: 15½ inches wide, 15 inches deep, 14½ inches high
Keyboard: 19 inches wide, 9 inches deep, 3 inches high
Monitor: 12 inches wide, 13 inches deep, 11 inches high

Processor
Custom instruction set implemented with AMD 2901 bit-slice processors and microcode in bipolar ROMs

Memory
256K (standard)

Display
Bit-mapped 12-inch monochrome display with 592 lines; 768 dots per line

Keyboard
VT-100-style detached keyboard with 83 keys, numeric keypad

Mouse
Roughly hemispherical with three buttons; 4-foot cord connects to keyboard

Mass Storage
15-megabyte 5¼-inch hard disk; 140K 5¼-inch (Apple format) floppy disk

Software
Medos-2 operating system, Modula-2 compiler, debugger, editor, **lara** (document processor), **sil** (schematic editor), **draw** (graphics drawing editor)

Price
$8000

Expansion Options
Hardwood computer cabinet, $150; 512K memory, $450; 830- by 640-pixel display, $1020; laser printer with interface, $10,000

Documentation
Lilith handbook, 100 pages; Lilith computer hardware manual, 450 pages

mer can even change the functions provided by the operating system.

In order to execute a program under Medos-2, you simply type in the program's name in response to a prompting asterisk. While waiting for you to type successive letters of the program name, Lilith quickly scans the hard-disk directory for executable programs. You need only to type in enough characters in the filename to uniquely identify the program. For example, to execute the program **directory** you can simply type **dir**. If there is no other program on the hard disk with the first three letters **dir**, Lilith completes the command for you by displaying **-ectory**; you accept this by pressing the Return key or the space bar.

Lilith will also help you out if you have only a hazy idea of the name of the program you want to run. If you press the ? key while typing in a program name, Lilith displays all program names that match what you've typed in so far. For example, if you enter

```
*m?
```

Lilith displays all programs that begin with *m* and redisplays the **m** prompt:

```
matrix
makewidfile
memfilexfer
mia
modula
missle

*m
```

You then can finish typing in one of the displayed program names or start over.

Lilith provides most of the common utility functions familiar to personal computer users as separate programs: there are programs to display the disk directory, make copies of files, rename files, delete files, back up and restore hard-disk files to and from floppy disks, and so on. The source code for most of these utility programs is provided.

THE edit PROGRAM

The **edit** program is used to create and modify text files; it is a simple but powerful program that provides basic text-editing functions and additional sophisticated features. I'll discuss the operation of the editor in some detail to give you an example of the way Lilith software uses the mouse and high-resolution display.

In most instances, **edit** splits the screen into three areas: a large text window that shows the text being edited, a horizontal message area at the bottom of the screen, and a vertical *scroll bar* at the left edge of the screen (see photo 6). As with many screen-oriented editors, you insert text at the current cursor position sim-

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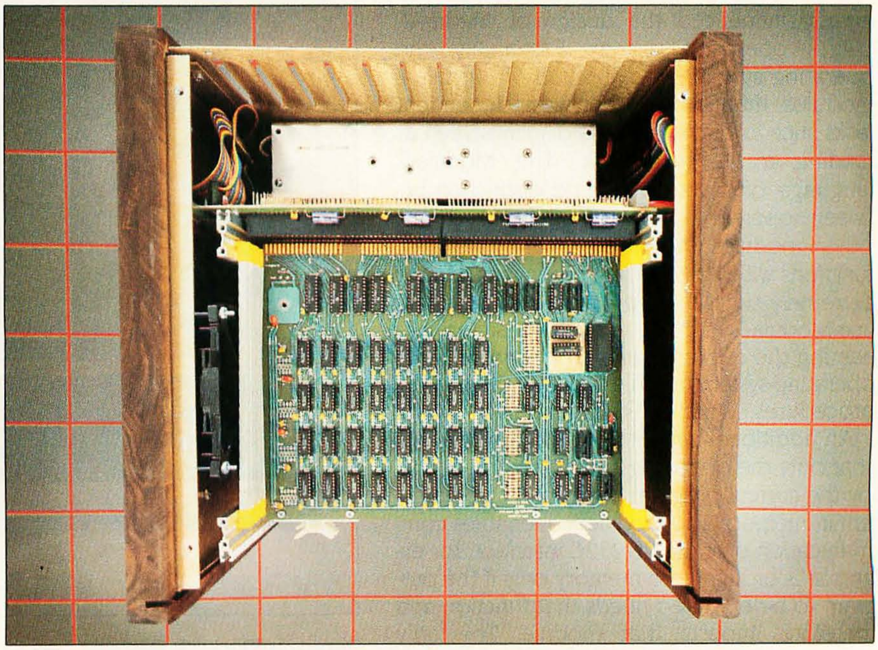

Photo 2: *Top view of the Lilith system unit with its front panel removed.*

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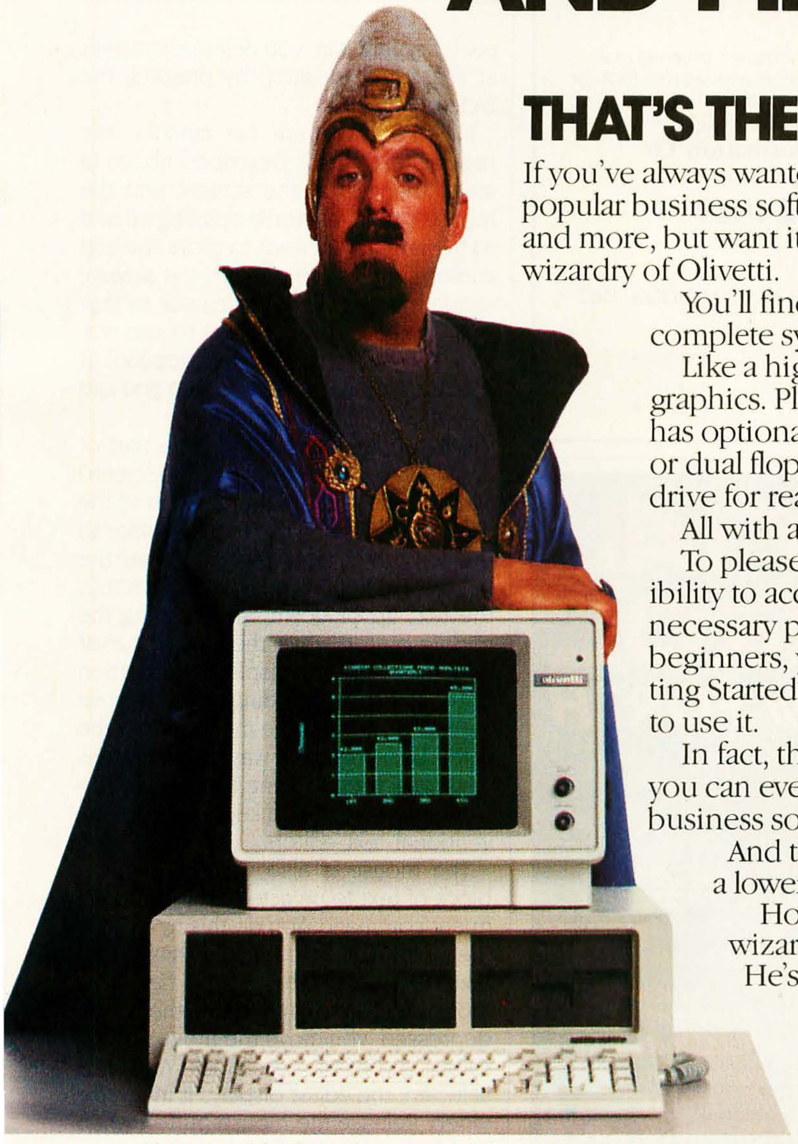

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[1] *Lotus Development* [2] *Ashton-Tate* [3] *MicroPro* [4] *IBM Corporation*

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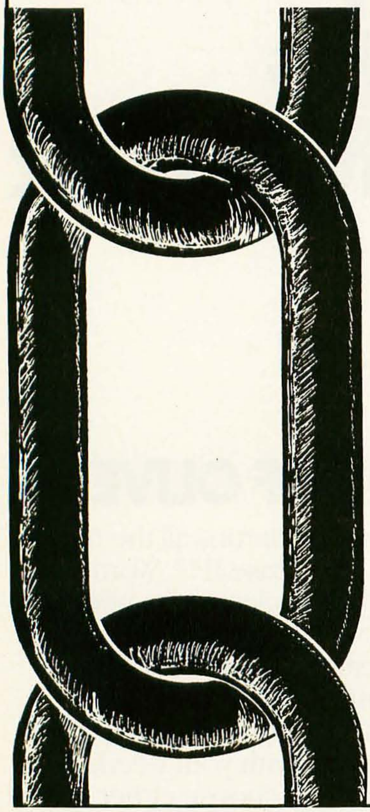

Lilith was designed to be a programmer's workstation for software development, and it succeeds quite well.

ply by typing it in; you delete characters at the cursor position by pressing the Delete key.

In **edit**, there are *two* cursors: the regular text cursor described above (a small triangle on the screen) and the mouse cursor (an arrow pointing up and to the left). If you want to move the text cursor somewhere else on the screen, simply move the mouse cursor to that point and press the leftmost mouse button. The text cursor then reappears at that location in the text so that you can insert or delete text there.

What if you want to modify a part of the file that isn't currently on the screen? You can scroll to another section of the text file by moving the mouse cursor to the scroll bar; then, pushing either the left or right buttons on the mouse scrolls the text up or down, and pushing the middle button while the mouse cursor is in the scroll bar displays the portion of the file corresponding to the relative vertical position of the mouse within the scroll bar. Used this way, the mouse is a simple replacement for the cursor-movement command keys in more conventional text editors.

The mouse is also used to select a block of text to be acted on by a subsequent command. You do this by moving the mouse cursor to the beginning of the text block and pressing the rightmost mouse button. Then, keeping the button depressed, you move the mouse cursor to the end of the text block. As text is selected, the editor displays it in inverse video. Release the mouse button when you have selected the desired text.

Additionally, the mouse can be used in the editor to display menus of possible commands and to select menu options. Pressing the middle mouse button and holding it down displays the editor menu, as shown in photo 6. You choose a menu option by moving the mouse cursor to it (the current option is dis-

(continued)

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> *The editor lets you split the screen into independent windows to display different portions of a file simultaneously.*

played in inverse video) and releasing the button. For example, you can delete an entire block of text by first selecting it with the mouse. You then activate the editor menu by pressing the middle button, highlight the Delete option by moving the mouse to it, and release the button to perform the deletion. Similar options within the editor menu let you move and copy selected blocks of text and search the file for a specified string.

The editor also lets you split the screen into two or more independent windows to display different portions of a file simultaneously. You may edit different files in each window.

OTHER SUPPLIED PROGRAMS

A great deal of software is provided with Lilith; I'll briefly describe some of the major programs.

A program that can be of great help in software development is **debug**, the debugger. Whenever a program ends abnormally, Lilith automatically writes the contents of memory to the hard disk; you can then use the debugger to inspect this memory dump. Photo 7 shows a screen display generated by the debugger. Probably the first thing you notice is the multiple windows; each one tells something of interest about the crashed program. The "procedure call chain" window, for example, shows the calling sequence of the procedures active when the program stopped. You can inspect the program's source code in the "program" window, values of simple variables in the "data" window, and values of structured variables (arrays and records) in the "variable" window.

Another important program, **lara**, is a *document processor*. Unlike the no-frills text editor, **lara** is designed to edit documents that may use different fonts, underlining, various justification modes,

(continued)

and so on. These options are displayed on the screen in true "what you see is what you get" fashion. If you specify that a phrase be italicized, for example, it is displayed in italics on the screen. (See photo 8 for a sample display.) A companion program called **laraprint** generates a printed copy of documents created by **lara** on a laser printer.

Lilith also provides two powerful "picture processors": programs that let you easily create and modify charts, drawings, and illustrations. The **sil** program is primarily meant for editing schematic diagrams and other line drawings. Related software includes libraries of predrawn logic gates and electronic symbols. The **draw** program handles more complicated illustrations (see photo 9).

Finally, the Lilith software includes a number of games, including Othello, pool, and versions of Pac-Man and Missile Command.

OPTIONS, PRICES, WARRANTY

The basic Lilith machine costs $8000; this system has 256K bytes of memory. Expansion to 512K bytes costs an additional $450. Expansion to 1 megabyte of memory will be "available soon," according to Modula Computer Systems; the price is not yet established. A hardwood cabinet for Lilith costs $150.

In addition to the 592- by 768-pixel display, Lilith can support a "portrait" video display with even higher resolution. The monitor used has a white phosphor (instead of green) and measures 17 inches diagonally. The resolution is 832 lines of 640 pixels each, a taller and narrower display. This option is tagged at $1020.

A laser printer with a Lilith interface is needed (at least for now) to get printed copies of documents and drawings composed by **lara**, **sil**, and **draw**. The price is $10,000.

Source code for the major programs on Lilith is available at relatively low cost. For example, the compiler source code is $160, the source code for the editor is $40, and the source code for the debugger is $80.

As of this writing, all sales and service of Lilith computers are direct from the factory. Modula Computer Systems offers a 90-day warranty on the computer; repairs are handled by free replacement of any defective subsystem (disk drive, memory board, etc.). After 90 days, defective subsystems are replaced for $200 per subsystem.

PROMINENT FEATURES

Lilith was designed to be a programmer's workstation for software development, and it succeeds quite well. The system is both easy to learn and easy to use. As I developed some simple programs in Modula-2, I found that the usual edit-compile-debug process is straightforward: all components of the system work well together.

Source code for many utility programs, library modules, and system programs is on disk. This lets a programmer study examples of Modula code.

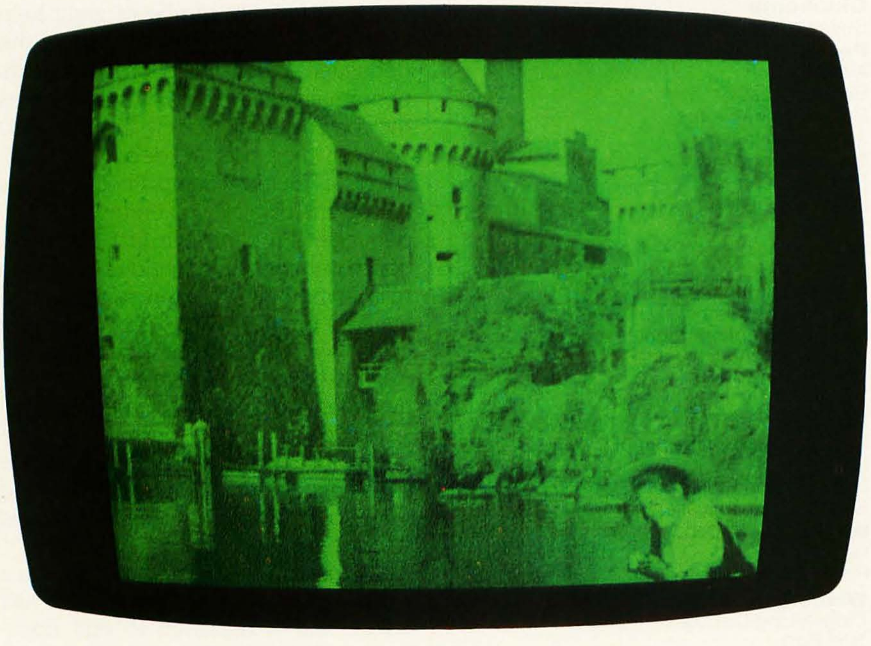

Photo 3: *Lilith's high-resolution video display. This display was generated by digitizing the output from a video camera.*

One of Lilith's most gratifying features is the consistent way the supplied software is implemented. When I was learning how to use the system, I was able to use many programs by simply trying things that had worked for me in other programs. I didn't have to try to remember different rules for different programs.

Lilith's mouse is also a plus. I have heard that there's quite a debate going on concerning the proper number of buttons on a mouse: Are three buttons too confusing? Is one button too limiting? I had no problems adapting to Lilith's three-button mouse, although occasionally I did press the wrong button. Fortunately, Lilith never does anything drastic or irrevocable when such errors are made.

Lilith's virtues include the power of the library modules provided for Modula programmers. The library modules make it relatively easy to write programs that take advantage of Lilith's outstanding hardware capabilities. A programmer can quickly construct attractive and sophisticated programs by simply utilizing library modules that let you use the mouse, different character fonts, windows, and so on.

Another uncommon feature of Lilith is that the source code for many utility programs, library modules, and major system programs is provided on disk. This lets an interested programmer study examples of Modula code and makes it easier to upgrade the system.

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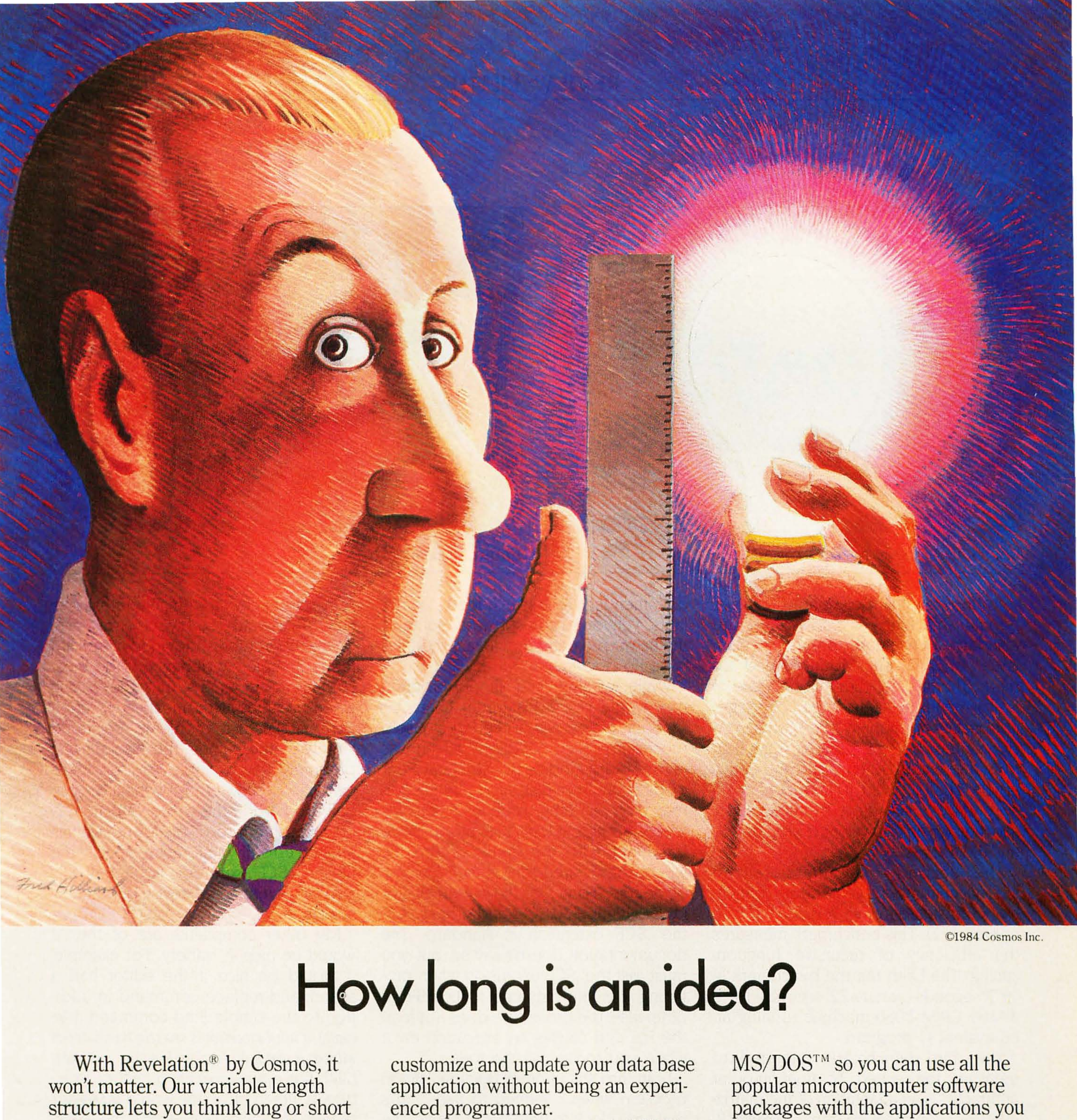

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Photo 4: A *close-up of Lilith's keyboard.*

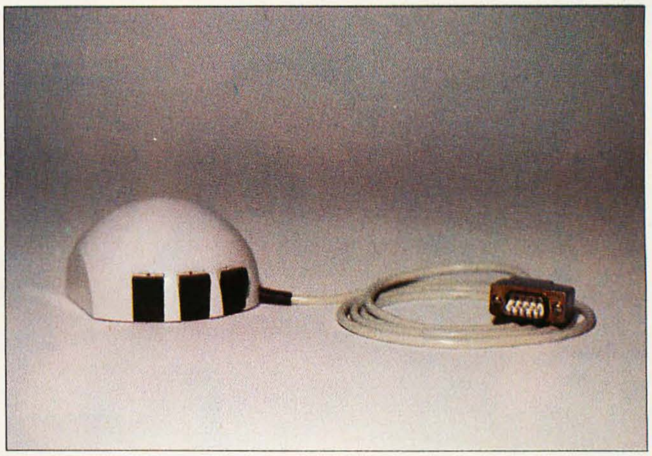

Photo 5: *Lilith's mouse.*

To find how Lilith compared to more popular machines, I translated three standard benchmark programs from issues of BYTE into Modula-2 and ran them. The first benchmark, the Sieve of Eratosthenes, tests the speed of integer arithmetic and looping. The Modula version of the Sieve benchmark was taken from reference 1, listed at the end of this article. The Lilith did 10 iterations in 4.7 seconds, versus (for example) 22.1 seconds for an equivalent C program on an IBM PC.

The second benchmark is the Fibonacci-number generation benchmark translated from a version in C (see reference 2). This benchmark measures the efficiency of recursive function-calling. The Lilith ran the benchmark in 19.7 seconds, versus 72 seconds for a 4-MHz CP/M 8080 machine running an equivalent C program.

The third benchmark, intended to measure the speed of floating-point arithmetic, is an adaptation of the matrix-multiplication program from reference 3. The Lilith ran this in 0.633 second, compared with 16.8 seconds for a 6-MHz CP/M 8085 machine running Pascal/MT+.

LIMITATIONS AND DRAWBACKS

The documentation is the primary difficulty in using Lilith. Even for its presumed target audience of experienced programmers, much of the documentation is too terse, breezing over complicated issues and providing few examples. Some sections of the documentation are out of date, for example, referring to keys not on the keyboard or not documenting features added to the latest version of the software; some of the newer programs and library modules have no documentation at all.

While working on a simple program that would display different character fonts on the screen, I needed to use a procedure called **LoadFont**, which was in the library module **Screen**. **LoadFont** loads a font from disk into memory; you may then call other routines to display characters in that font. You must provide **LoadFont** with the name of the file where the desired font is to be found, of course. Font files have names like **OLDENGLISH20.SCF** and **Chess.SCF**; the **.SCF** extension is standard. The documentation doesn't say so, but you must *omit* the **.SCF** extension when providing the font filename to **LoadFont**; otherwise, the procedure does not load the file and causes an execution error when you try to use the font.

I ran into still another documentation problem when I wanted to use Lilith's real-time clock to time benchmarks: the documentation provides no information for accessing the clock, let alone how to use it as a timer. (I solved the problem by perusing the source code for a supplied program that used the clock.)

One regrettable feature of Lilith's operating system is that it imposes a limit of 768 files on the hard disk. (This limit is the cause of the Winchester disk being divided into 5- and 10-megabyte portions.) Since most files on Lilith tend to be relatively small, you'll reach this 768-file limit while there is plenty of unused space on the disk. Worse, when this limit is reached, the editor and compiler start behaving strangely, refusing to create files and not saying why.

Several programs provided with Lilith aren't completely debugged; the most common problem is that they crash when provided with unexpected input. Fortunately, such problems are found largely in the games: the pool-playing program, for example, exits with a cardinal-overflow error if you hit the cue ball too hard in the wrong direction. A utility program to display fonts signals a range error if you forget to specify the normal **.SCF** extension for a font file. Such bugs mar an otherwise outstanding system.

My other complaints are of the "it would be nice if" variety. For example, it would be nice if the editor had a search-and-replace command in addition to the simple Find command. [*Actually, a word processor is severely handicapped without a search-and-replace function. . . .* G.W.]. Lilith has a one-level file directory structure; a hierarchical one would be easier to use. The cable connecting the video monitor to the system unit is much too short and severely constrains convenient placement of the video-display unit.

[**Editor's Note:** *While using the Lilith during the editing of this review, I found most of the supplied programs hard to use or poorly documented. Of course, our definition of ease of use changes with the passing years. When the* **lara** *word processor was created, perhaps nobody minded having to type in the name of the font—*TIMES-ROMAN12B, *for example—to change the size and style of text.* (*However, this is what you have to do* every *time you want to change type fonts in* **lara**.) *Products like* Macintosh *and* Lisa, *which*

allow font selection from a pull-down menu, have increased our expectations of what makes a program easy to use. . . . G.W.]

Other quibbles speak to Niklaus Wirth's goal of rich interaction between Lilith and the user. A sound-generation capability would be a welcome addition to the Lilith's graphics-oriented display and its mouse pointing device. Unfortunately, no sound-generation capability is provided on Lilith, not even the usual Control-G beep found on most machines. A color display would also improve the user interface. Lilith is an open-ended system, fortunately; it should be relatively simple to add those capabilities to existing machines, if the hardware becomes available.

SUMMARY

Lilith is a powerful and versatile computer system that's nearly an ideal tool for software development. The underlying soundness of Wirth's design goals is verified by the number of manufacturers coming out with machines with features similar to Lilith's: high-resolution bit-mapped screens, a plethora of fonts that can be displayed, mice (and other pointing devices), windowing, and so on.

Lilith has the potential to be an excellent machine for people other than programmers. A computer that is easy for programmers to use can also be made to perform well for more general purposes. Lilith's success will depend largely on how quickly high-quality (and well-documented) applications software becomes available. ■

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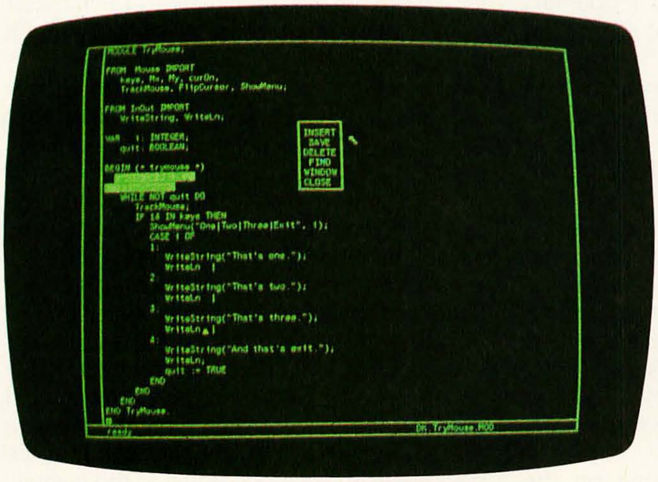
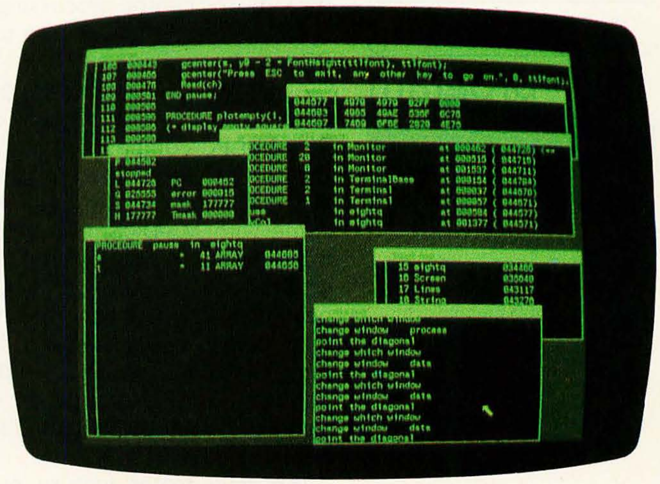
1. Gilbreath, J., and G. Gilbreath. "Eratosthenes Revisited: Once More through the Sieve." BYTE, January 1983, page 283.
2. Kern, C. "Five C Compilers for CP/M-80." BYTE, August 1983, page 110.
3. Pournelle, J. "A BASIC and Pascal Benchmark, Elegance, Apologies, and FORTH." BYTE, October 1982, page 254.

For more information on the history and design philosophy of Lilith, see two articles in the August BYTE: *"History and Goals of Modula-2," by Niklaus Wirth, page* 145, *and "Lilith and Modula-2," by Richard Ohran, page* 181.



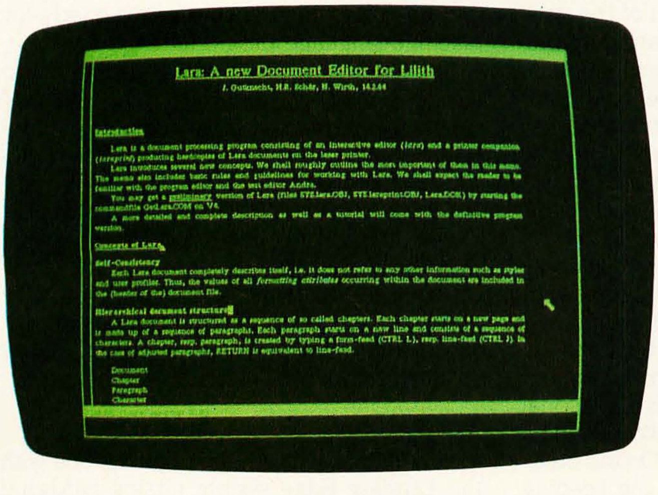
```
MODULE TryMouse;

FROM Mouse IMPORT
  keys, Mx, My, curOn,
  TrackMouse, FlipCursor, ShowMenu;

FROM InOut IMPORT
  WriteString, WriteLn;

VAR   i: INTEGER;
   quit: BOOLEAN;

BEGIN (* trymouse *)
  [illegible]
[illegible]
  WHILE NOT quit DO
    TrackMouse;
    IF 14 IN keys THEN
      ShowMenu("One|Two|Three|Exit", i);
      CASE i OF
      1:
        WriteString("That's one.");
        WriteLn  |
      2:
        WriteString("That's two.");
        WriteLn  |
      3:
        WriteString("That's three.");
        WriteLn  |
      4:
        WriteString("And that's exit.");
        WriteLn;
        quit := TRUE
      END
    END
  END
END TryMouse.
```

Photo 6: A *typical display generated by* edit, *the program editor.*



```
106  000445     gcenter(s, y0 - 2 * FontHeight(ttlfont), ttlfont);
107  000466     gcenter("Press ESC to exit, any other key to go on.", 0, ttlfont);
108  000470     Read(ch)
109  000501  END pause;
110  000505
111  000506  PROCEDURE plotempty(i,
112  000506  (* display empty square
113  000500

044577 | 4070  4070  027F  0000
044603 | 4905  40AE  530F  0C78
044607 | 7409  0FDE  2020  4E75

P 044502
stopped
L 044720    PC     000452
G 020355    error  000015
S 044734    mask   177777
H 177777    Tmask  000000

OCEDURE   2    in Monitor         at 000462 ( 044720) <==
OCEDURE  20    in Monitor         at 000515 ( 044710)
OCEDURE   8    in Monitor         at 001537 ( 044711)
OCEDURE   2    in TerminalBase    at 000154 ( 044704)
OCEDURE   2    in Terminal        at 000037 ( 044670)
OCEDURE   1    in Terminal        at 000057 ( 044671)
use            in eightq          at 000584 ( 044577)
xCol           in eightq          at 001377 ( 044571)

PROCEDURE  pause  in  eightq
a                 *  41 ARRAY   044000
t                 *  11 ARRAY   044050

15 eightq      034400
16 Screen      030040
17 Lines       043117
18 String      043270

change which window
change window    process
point the diagonal
change which window
change window    data
point the diagonal
change which window
change window    data
point the diagonal
change which window
change window    data
point the diagonal
```

Photo 7: A *display generated by* debug, *the system debugger.*



Lara: A new Document Editor for Lilith

J. Gutknecht, H.R. Schär, N. Wirth, 14.2.84

Introduction

Lara is a document processing program consisting of an interactive editor (*lara*) and a printer companion (*laraprint*) producing hardcopies of Lara documents on the laser printer.

Lara introduces several new concepts. We shall roughly outline the most important of them in this memo. The memo also includes basic rules and guidelines for working with Lara. We shall expect the reader to be familiar with the program editor and the text editor Andra.

You may get a preliminary version of Lara (files SYS.lara.OBJ, SYS.laraprint.OBJ, Lara.DOK) by starting the commandfile GetLara.COM on V4.

A more detailed and complete description as well as a tutorial will come with the definitive program version.

Concepts of Lara

Self-Consistency

Each Lara document completely describes itself, i.e. it does not refer to any other information such as styles and user profiles. Thus, the values of all *formatting attributes* occurring within the document are included in the (header of the) document file.

Hierarchical document structure

A Lara document is structured as a sequence of so called chapters. Each chapter starts on a new page and is made up of a sequence of paragraphs. Each paragraph starts on a new line and consists of a sequence of characters. A chapter, resp. paragraph, is created by typing a form-feed (CTRL L), resp. line-feed (CTRL J). In the case of adjusted paragraphs, RETURN is equivalent to line-feed.

Document
Chapter
Paragraph
Character

Photo 8: A *display generated by* lara, *a document processor.*

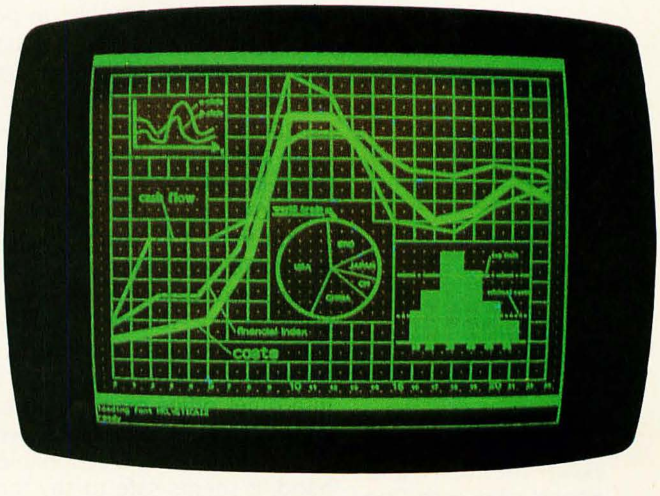
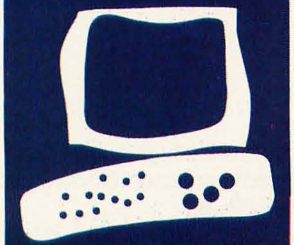


Photo 9: A *display generated by* draw, *an illustration editor.*

SYSTEM REVIEW



The Leading Edge Personal Computer

A fast-running desktop system with an impressive word-processing program

BY JEFFREY MAZUR

Add the Leading Edge Personal Computer to the growing list of computers that are compatible with the IBM Personal Computer (PC). The Leading Edge is a three-piece desktop system similar in appearance to the IBM PC. It features 128K bytes of RAM (random-access read/write memory), dual disk drives, built-in parallel and serial ports, and a clock/calendar with battery backup. The central processing unit operates up to 50 percent faster than that of the IBM PC.

At $2695, the Leading Edge system compares favorably with similarly equipped IBM PCs and PC compatibles. While it does not offer an extensive array of bundled software like some others, the Leading Edge does come with MS-DOS, GW-BASIC, and a fine word-processing program. The machine wouldn't win any beauty awards, but it appears to be well designed, very reliable, and quite powerful. The Leading Edge is manufactured by Mitsubishi in Japan. This same computer, with a slightly different keyboard, has also been sold as the Sperry Personal Computer.

The only major feature missing on the Leading Edge is graphics capability. While the basic IBM PC doesn't have this either, most of the newer PC compatibles offer monochrome or color graphics as part of the standard system. Of course, if you want graphics, you can add one of the many graphics boards available for the IBM. Five empty IBM-compatible expansion slots are inside the main system unit. Leading Edge will soon offer a two-board, color graphics adapter with ultra-high (640- by 400-pixel) resolution.

One thing this computer is not lacking is adequate ventilation. A large fan takes care of this and makes the power light somewhat unnecessary. You can easily tell if the computer is on by just listening. In a business environment this noise might go unnoticed. But in a quiet office or a den (this is a personal computer, right?), the noise level produced by this fan is almost objectionable. On the other hand, it seems safe to say that the Leading Edge will not suffer any heat problems, even after filling up its peripheral slots.

HARDWARE

Like any good "clone," the Leading Edge system tries to retain a high degree of similarity to the IBM PC while offering a number of improvements. As with the IBM, the Leading Edge consists of three separate units: the main system unit, a monitor, and a detachable keyboard. A three-foot monitor cable makes for a more flexible arrangement. The monitor even has a built-in stand, which lets you tilt the display for easy viewing.

As for the main system unit, it has roughly the same (oversize, in my opinion) dimensions as the IBM PC but is not as aesthetically pleasing as the IBM and some other similar machines. The front panel is made of plastic. The rest of the box is surrounded by a sheet-metal cover. The two disk drives are mounted horizontally on the right side of the machine. Just below the drives are the power switch and indicator. Hooray for an easy-to-find power switch; some manufacturers find the place that's hardest to reach on their machine and then put the power switch there. By the way, the power indicator is actually a little more than meets the eye; according to the manual, this LED (light-emitting diode) is software controlled, which means it can be used by a program to signal some condition. I doubt it will get much use, but it could prove handy for machine-language programmers.

On the left side of the box is the keyboard connector. This standard five-pin DIN (Deutsche Industrie Norm) connector supports compatibility with any keyboard designed for the IBM PC. The rear of the computer has the monitor and main power sockets, the serial port, the external drive port, the parallel port, and the monochrome video connectors. Just to the right of the serial connector are eight DIP (dual-inline pin) switches, which control the processor speed, hardware self-test, and boot device.

VIDEO DISPLAY

The monochrome monitor that comes with the Leading Edge system retains hardware compatibility with the IBM; that is, it uses a TTL (transistor-transistor logic) interface with

Jeffrey Mazur (POB 636, Chatsworth, CA 91311), a videotape engineer with ABC TV, is the author of a book on the Timex 2068 to be published by Howard W. Sams & Co.

separate video, sync, and intensity control and 18-kHz/50-Hz scanning frequencies. Each character is created within a 9 by 14 dot matrix. Subtracting spaces between characters and lines leaves a 7 by 9 character matrix (plus two more rows for descenders). The Leading Edge uses a sans serif font.

The literature on the Leading Edge specifies a green-phosphor monitor. I was pleasantly surprised when my unit came with an amber screen. Either the company is switching colors or it ran out of green screens. I found this amber monitor to be one of the best I've seen.

KEYBOARD

The Leading Edge keyboard is sort of a cross between the IBM PC and Key Tronic keyboards. Unfortunately, it incorporates the worst features of each. The layout of the keys is identical to the IBM (see photo 2), disregarding the complaints of touch-typists concerning certain key placements. Of course, this layout adds slightly to the compatibility with the IBM PC; for example, keyboard overlays designed for the IBM will work with this keyboard.

The feel of the keys is similar to the Key Tronic keyboards with no audible or tactile feedback. The keys respond to the lightest touch. Some people find these keyboards too sensitive and may require a little getting used to. I hunt and peck, so I think most of the new PC-type keyboards are a dream to use compared to some others. I wonder if we'll ever see variable "touch" controls on a computer keyboard like those on electric typewriters.

There are no indicators on the keyboard for the Num Lock and Caps Lock functions, and the Shift, Tab, and Return keys are denoted with arrows, as on the IBM PC keyboard. Automatic repeat is supported on all keys, as well as true N-key rollover (you can hold down as many keys as you like and the keyboard still reads each key correctly). Two little feet at the rear of the keyboard enable you to tilt it slightly.

MICROPROCESSOR

Inside the Leading Edge computer resides an 8088-2 microprocessor. This is an 8-MHz version of the chip used in the IBM PC. Normally, this microprocessor runs at 7.16 MHz, which is exactly 50 percent faster than the IBM's. When the processor is accessing motherboard RAM or ROM (read-only memory), it can run at the faster speed. During direct memory access, I/O (input/output) operations, or peripheral card access, it slows down to the 4.77-MHz speed used by the IBM. This assures compatibility for boards designed to plug into the IBM PC. You can also permanently switch the processor into 4.77-MHz

(continued)

Photo 1: *The Leading Edge Personal Computer with a monochrome monitor.*

The disk-drive MTBF *(mean time between failure) is listed at* 20,000 *hours, compared to* 8000 *hours for the* IBM PC.

operation with a DIP switch accessible from the rear of the machine. Two other switches indicate the presence of an 8087 numeric data coprocessor and select its clock speed.

Memory

Leading Edge is sure to draw criticism for its 128K-byte maximum motherboard memory. You must purchase an optional board to add memory—and you *will* want to add more. Of course, the benefit is that this board will let you easily increase the memory size up to the 640K-byte maximum. When I bought my machine, the Leading Edge memory board was being offered at a very reasonable price. Since the word-processing program (as well as many others) performs much better with 256K bytes, the additional board seems worthwhile. As with the rest of the electronics in the computer, this board is obviously extremely well made.

The motherboard has 16K bytes of ROM that contains the bootstrap and BIOS (basic I/O system) for the DOS (disk operating system). Another 4K bytes of ROM provides a self-test procedure that automatically checks out the hardware every time the system is reset. This self-test can be defeated by one of the DIP switches on the rear of the unit. However, even with 256K bytes of RAM, it takes only about one second to complete the test—much faster than a comparably equipped IBM PC. An empty socket is available for another 4K-byte ROM that can be used for software-protection schemes.

Floppy-Disk Drives

The Leading Edge system comes with two half-height, double-sided, double-density floppy-disk drives. Under MS-DOS 1.25, each drive holds 320K bytes. Storage will increase to 360K bytes when MS-DOS 2.0 is released for this machine.

Several types of disk doors are popular: the traditional one-piece, flip-up door; the sliding door; and the door with a locking lever. The drives on the Leading Edge use none of these mechanisms. Instead, the door consists of two parts. There is a pivoting push bar below the disk slot, and above it is a movable arm attached to the clamping apparatus. By pressing in on the lower piece, the upper arm snaps open, ejecting the disk in the drive. The new disk can then be pushed in until it seats. At this point, if you change your mind and want the disk back out, you simply tap the upper arm and the disk pops out. Otherwise, as you lower the arm to lock the disk in place, the drive spins momentarily. This assures that the disk is centered properly before it is clamped. These drives seem to be of excellent quality and have performed flawlessly to date. The MTBF (mean time between failure) is listed at 20,000 hours, which should give some indication as to their reliability. IBM's drives are rated at 8000 hours MTBF.

Power Supply

Leading Edge's system uses a switching-type power supply capable of delivering approximately 100 watts. This is a considerable improvement over the IBM PC and should prove reliable with any combination of peripheral cards. Since a hard disk is not meant to be mounted internally, there should be no problems with the power supply. Thanks to the abundant cooling provided by the fan, which is mounted on top of the power supply, there should be little concern about overloading this computer

Interfaces

The Leading Edge computer uses a monochrome video/printer adapter card similar to the one in the IBM. The printer port is Centronics compatible but uses a female DB-25 connector. Cables are readily available to connect the computer and the printer. A serial port is also provided. The hardware is identical to the IBM PC's, and most off-the-shelf communications packages should work. Perfect Link ran perfectly; PC-Phone worked fine in the terminal mode but had a little difficulty during Christensen protocol transfers (the files eventually made it but not without a considerable number of time-out errors). I tested these programs using a direct serial link between an Eagle II computer (running Modem7) and the Leading Edge computer.

The floppy-disk controller card in the Leading Edge can handle up to four drives. Two external drives can be attached via a connector on the back of the machine. These drives (as well as the

(continued)

Photo 2: *The keyboard of the Leading Edge. Note that the key layout is identical to that of the* IBM PC's *keyboard.*

AT A GLANCE

Name
Leading Edge Personal Computer

Manufacturer
Leading Edge Products Inc.
225 Turnpike St.
Canton, MA 02021
(617) 828-8150

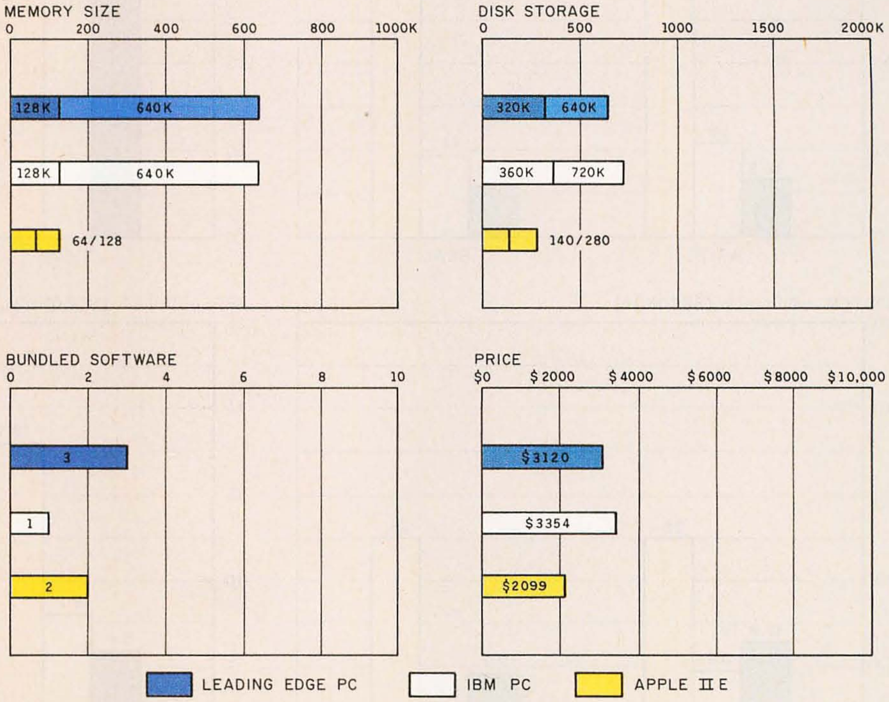
Components
Processor
8088-2, 16-/8-bit, 7.155-/4.77-MHz
Display
11½-inch diagonal green or amber external monitor; 80 characters by 25 lines
Keyboard
83 keys; layout identical to the IBM PC's
Storage
Two internal, half-height, 5¼-inch floppy-disk drives
I/O Interfaces
Parallel printer port, RS-232C asynchronous serial port, floppy-disk connector for two more drives

Software
MS-DOS 1.25, GW-BASIC, diagnostic disk, Leading Edge word-processing program

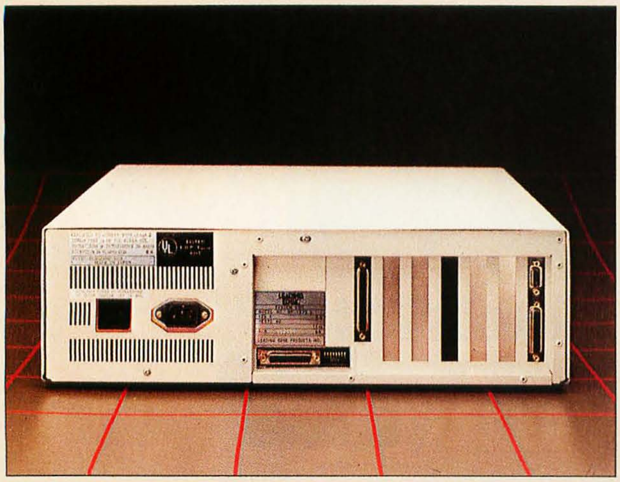
Options
Memory board with 128K RAM, socketed to accept a total of 512K; ultrahigh-resolution color graphics board set; Multiplan spreadsheet program

Documentation
Operator's guide and technical reference manual, 300 pages; MS-DOS manual, 420 pages; BASIC manual, 270 pages; Leading Edge word-processor manual and training aids, 250 pages

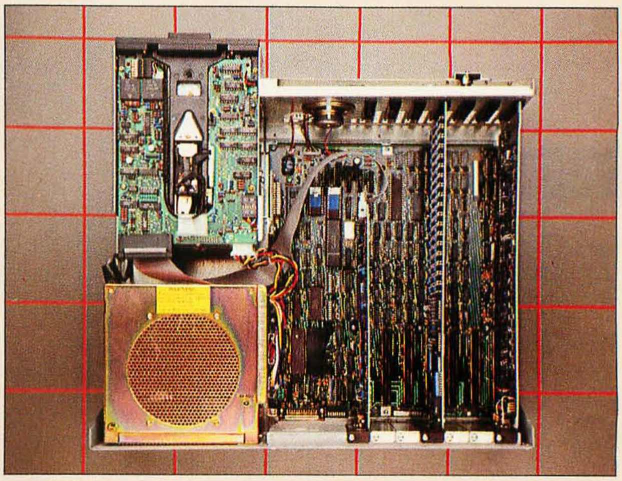
Price
Standard system (128K), $2695; with 256K memory and graphics board, $3120



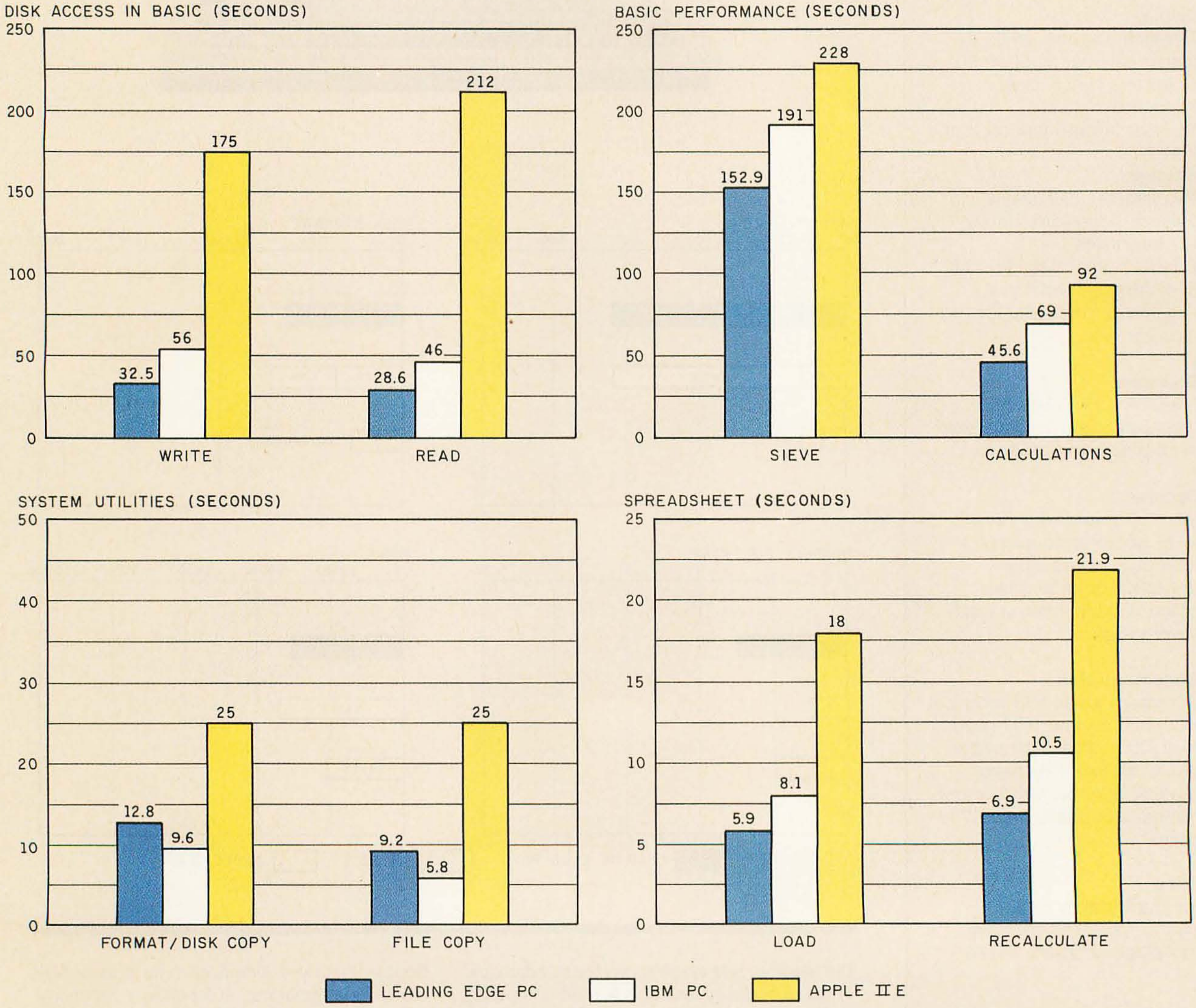
The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity of a floppy-disk drive on each computer. The Bundled Software graph shows the number of software packages included with each system. The Price graph shows the costs of the Leading Edge and the IBM PC with two 5¼-inch, double-sided, double-density, floppy-disk drives; a monochrome monitor with connection apparatus; color-display capability; a printer port and a serial port; 256K bytes of memory; the standard operating systems for the computers being compared; and their standard BASIC interpreters. The Apple IIe includes a monochrome monitor, two disk drives, 64K bytes of memory, a printer port, and a serial port.



The rear panel of the Leading Edge. Note the serial connector and microswitches in the lower center.

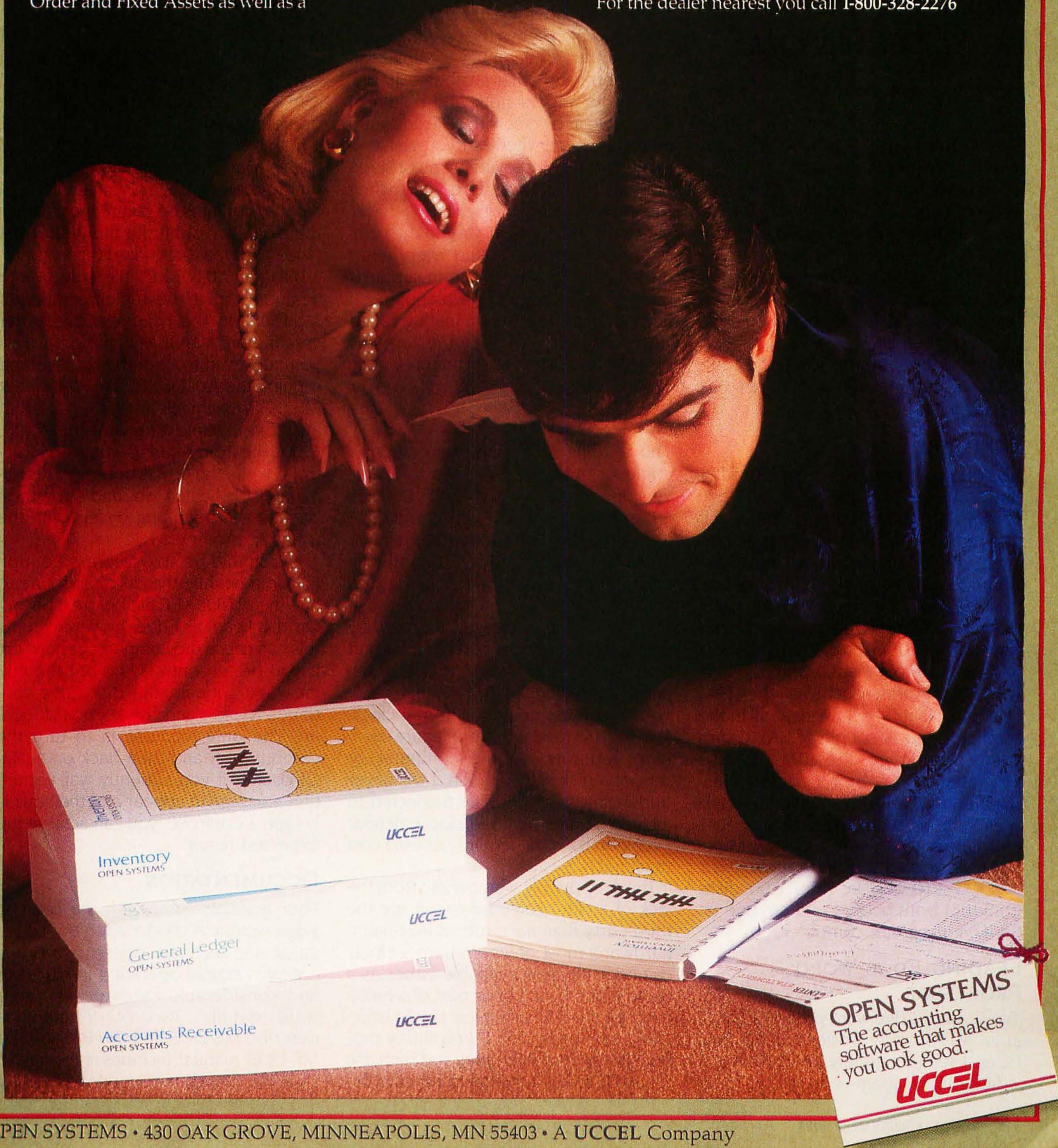


The inside of the Leading Edge. The disk drives are at the upper left (front) of the machine.



The graphs of BASIC program performance and disk access in BASIC show the times for running the benchmark programs (see "The Chameleon Plus," by Rich Krajewski, June BYTE, page 327). The Leading Edge used GW-BASIC running under MS-DOS 1.25, and the clock speed of the microprocessor was 7.16 MHz. The IBM PC was tested using BASICA running under PC-DOS 2.0 with a clock speed of 4.77 MHz. The System Utilities graph shows how long it takes to format and copy a disk (adjusted for 40K bytes of disk data) and to transfer a 40K-byte file using the system utility programs. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell spreadsheet. The spreadsheet used was Microsoft Multiplan.

Circle 282 on inquiry card. →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UCCEL
General Ledger
OPEN SYSTEMS
UCCEL
Accounts Receivable
OPEN SYSTEMS
UCCEL
OPEN SYSTEMS™
The accounting software that makes you look good.
UCCEL

Software packages such as WordStar, CalcStar, VisiCalc, Lotus 1-2-3, dBASE II, *and* MultiMate *all worked without a hitch on the* Leading Edge.

two internal ones) can be either standard-density (320K-byte) or high-density (1.3-megabyte) units.

The Leading Edge Personal Computer also contains a built-in clock/calendar circuit with battery backup. This circuit enables the computer to keep track of the current date and time, even when the computer is turned off. A small nickel-cadmium (nicad) battery keeps the circuit running for as long as two months without power. When the computer is turned on, this battery is recharged.

SOFTWARE

No computer system is complete without software, and the Leading Edge comes with a small but powerful set of programs, including MS-DOS, the operating system necessary to make the computer tick, and GW-BASIC, a very extensive BASIC interpreter. Although MS-DOS and GW-BASIC are not exactly the same as PC-DOS and BASICA, most programs are compatible with the two. Some programs, such as the IBM tutorial disk, refuse to work at all in the Leading Edge. A couple of BASIC programs written on the IBM PC also generated curious error messages when run under GW-BASIC. Software packages such as WordStar, CalcStar, VisiCalc, Lotus 1-2-3, dBASE II, and MultiMate all worked without a hitch. Also, PC-DOS 1.10 and PC-DOS 2.00 disks from IBM both booted and ran fine on the Leading Edge computer.

LEADING EDGE WORD PROCESSOR

The Leading Edge word-processing program was actually written for the IBM PC and sells separately for $100. It is a wonderful program—one of the best I've seen—and it influenced my decision to get this computer.

A thorough review of the Leading Edge word processor would fill another article, so I'll give you just a few reasons why I like this program. First, it seems to do almost anything I would ever want to do with a word processor (short of showing different fonts on the screen like the Macintosh). Special formatting and printer codes are not embedded in the text, which keeps the screen free of such clutter. Underlining is shown on the screen, and other attributes (italics, subscripts, superscripts, and boldface) are shown in reverse video. Text is automatically saved whenever you pause to think. This feature saved me a considerable amount of work one night when the power failed momentarily; I was almost in shock when I turned the computer back on and found every letter perfectly intact. The program supports multiple glossaries of frequently used text or keystrokes. With a feature called "archived delete" you can restore any deleted text. The list of features goes on and on.

MS-DOS

The Leading Edge personal computer comes with MS-DOS version 1.25. This version is quite similar to IBM's PC-DOS 1.1 and thus provides "disk compatibility" with the IBM and other similar machines. When MS-DOS is normally booted (after power-on or via the Ctrl-Alt-Del soft reset), a title message displayed on the screen is followed by prompts to enter the current date and time. With most other MS-DOS machines, including the IBM PC, this is how you set the computer's internal clock. You have to repeat this procedure every time you turn on the computer or reboot a disk. What a pain! I will never understand why Big Blue neglected to include a battery-backed clock/calendar circuit on its PC. It certainly doesn't cost that much.

The only people who benefit from the lack of a clock/calendar circuit are the third-party manufacturers of PC-related hardware, most of whom have a clock/calendar function available either as a stand-alone board or as part of a multifunction card. To use these clocks effectively, you must also add a utility program to each of your disks and then use the AUTOEXEC function to execute the program automatically upon booting.

With the Leading Edge computer, however, the system date and time are automatically set by an internal battery-backed clock/calendar every time the system is booted. Thus the date and time queries after booting are usually superfluous (they can be used if the setting of the clock/calendar needs to be changed). You can bypass this portion of the booting process by having a file named AUTOEXEC.BAT on the disk. If such a file exists on the disk being booted, the contents of this batch file are executed immediately after the operating system is loaded. Therefore, it makes sense to create an AUTOEXEC file on every disk that might be booted on the Leading Edge. Even a null file (a file that contains no commands) avoids the necessity of hitting the Return key twice to bypass the date/time entry.

Using an AUTOEXEC file, I discovered a minor quirk in the implementation of MS-DOS on the Leading Edge. After creating an AUTOEXEC file on a disk, you may want to boot the disk without running the AUTOEXEC file. With other MS-DOS machines (including the IBM PC), if you want to prevent the AUTOEXEC file from running, you press Control-C while the disk is booting. This terminates the "batch job" and throws you back to the operating system with the usual A: prompt.

You should be able to press Control-C anytime while the disk is booting to halt the AUTOEXEC file before it begins. On the Leading Edge, however, doing this can cause the computer to hang up. If you press Control-C before the title message appears, the disk drive continues to spin and the keyboard locks up. The only recourse is to turn the computer off and then back on again. Of course, if you patiently wait for the title message to appear and then quickly type a Control-C, you can achieve the expected result.

DOCUMENTATION

Four manuals come with the Leading Edge system. A combination operator's guide and technical reference manual contains simple operating instructions and considerable hardware and software details. Two other manuals describe MS-DOS and GW-BASIC. (The MS-DOS manual includes information

(continued)

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In Canada call, Scarsdale Technologies (416) 441-1900

on the MS-MACRO86 Macro Assembler, MS-LIB Library Manager, and MS-CREF Cross Reference Utility, but these programs are not supplied with the computer.) The manual that covers the Leading Edge word-processing program is written exclusively for inexperienced users. But just as people can sometimes get a bit too friendly, documentation can be overly user friendly to the point where important information is left out. I had to call Leading Edge's software hotline a couple of times to get information that should have been in the manual.

SUPPORT

Leading Edge's customer support is another selling point for its computer. Two toll-free numbers are available for technical help: one is for questions about the computer, the other is for questions about software. When I called the software hotline, the person who answered the phone actually knew what she was talking about and was able to quickly answer my questions. My experience with the technical hotline was not as pleasant. When I called about the Control-C problem, I talked to a guy who didn't know much about what he was doing. After I patiently explained the problem to him, he rudely refused to believe that the computer was doing what I said. When I asked to speak to someone else, it was suggested that I call the software hotline. Doing so put me in touch with a more courteous person who had a computer in front of him. After confirming the problem, he thanked me for bringing it to the company's attention and said Leading Edge would try to find a solution. I guess I know which number to call if I ever have any more problems.

SUMMARY

As with all PC compatibles, you trade a little software compatibility and the letters *IBM* for extra features and state-of-the-art design. All of the built-ins on the Leading Edge (i.e., parallel and serial ports, clock, MS-DOS, word processor) cost extra with the IBM PC. The faster clock rate in the Leading Edge is certainly another point in its favor. And, of course, saving about $1000 off the price of a similarly equipped IBM doesn't hurt. The Leading Edge computer is a reasonable alternative to the IBM PC. ■

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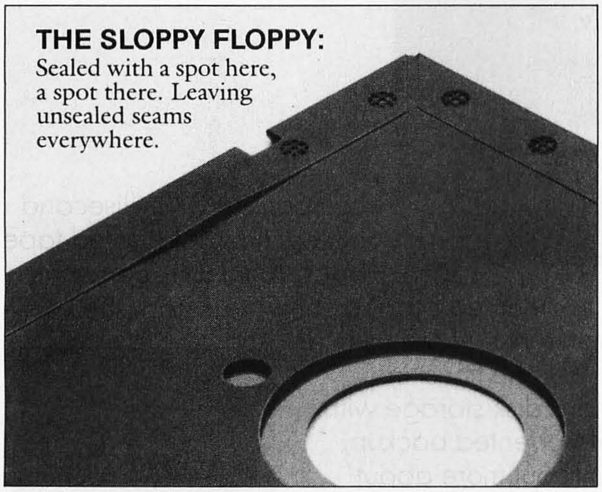
So much for their seams. Ours are different.



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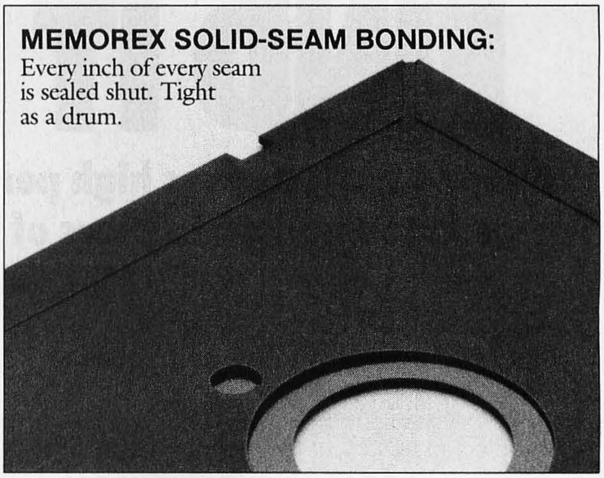

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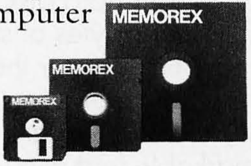

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MEMOREX

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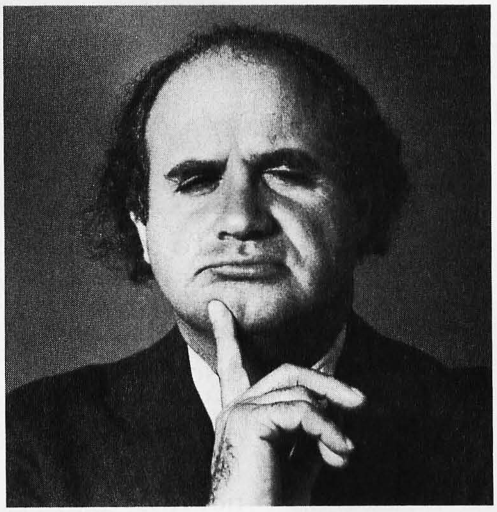
Alloy's PC-STOR gives high performance hard disk storage and file-oriented backup to users of IBM, Eagle, Columbia, and Corona.



In one compact, stackable, attractive package, the remarkable PC-STOR from Alloy combines the latest Winchester hard disk performance with the industry's finest file-oriented tape backup system. It lets you locate, retrieve, and reposition data quickly, precisely, and easily. For IBM PC and IBM compatible users, PC-STOR's new Winchester hard disk offers a choice of 20 to 170 megabytes of storage with access up to 4 times faster than the IBM-XT system. And it has been specially designed to be easy to use. Here are just some of its remarkable features: DOS 2.0 or CCP/M compatible. 38 millisecond access time. Integrated tape backup. TIP-SIX, powerful file-oriented backup software. Established network compatibility.

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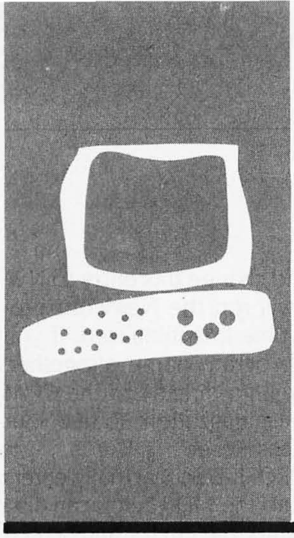
Circle 13 on inquiry card.



S·Y·S·T·E·M R·E·V·I·E·W

The Morrow MD-11

Featuring a large software library and unusual disk controller

BY JOHN HEILBORN

Given the proliferation of new computer systems, the drive for market share may cause manufacturers to make marketing claims that require close examination. In the case of Morrow Designs' new MD-11, the company said it aimed to deliver an attractively priced computer with above-average operating speeds and a higher-than-normal number of bundled software packages. Relatively modest goals, to be sure; so let's see how close they came to the mark.

The MD-11 arrived in two boxes: one contained the MD-11, 13 software disks (8 applications programs and the operating system), and nine manuals; the other box held the MDT-60 terminal and its documentation.

The system unit consists of a 384K-byte floppy-disk drive, an 11-megabyte hard-disk drive, and 128K bytes of RAM (random-access read/write memory) run by a 4-MHz Z80A processor. The Z80A uses 128K bytes of RAM because the operating system is Digital Research's new CP/M Plus (also known as CP/M 3.0). Ordinarily the Z80A can access only 64K bytes of RAM, but by using bank switching, the operating system can handle 128K bytes of RAM by looking at it in 64K-byte chunks. In fact, the MD-11 uses whatever portion of the bank is currently available as an intelligent RAM and thereby improves overall throughput.

A look at the back of the MD-11 reveals five I/O ports: auxiliary, RS-422, printer/modem, parallel, and terminal.

In reality, the auxiliary, printer/modem, and terminal ports are RS-232C serial connections. The RS-422 port uses the same address as the auxiliary port and is designed for high-speed communication with a mainframe computer. If you decide to use the RS-422 port you will need to get your own software to support it because the MD-11 operating system currently does not recognize it.

THE MDT-60 VIDEO-DISPLAY TERMINAL

The MDT-60 keyboard has 91 keys including 9 function keys, and separate Set Up, Help, Home, and Erase keys. A smaller keypad holds the numeric keys. Although the arrangement of the cursor-control keys is slightly unusual (see figure 1; note that the Up cursor key is in the center position and the Home key is to the left of the cursor cluster), it only took me a few minutes to get used to it.

The 12-inch green-phosphor display screen supports standard, reverse, and half-intensity video. You can also program the cursor to be either a solid block or a simple underline, steady state or flashing. Table 1 lists the commands that control these functions. In addition to these commands, you can toggle the entire screen between standard and reverse video by entering Esc-K-0 for standard video or Esc-K-1 for reverse video.

To enter either of these commands, simply type them in at any CP/M prompt.

SETTING UP THE SYSTEM

After you unpack the system components (system unit, keyboard, and display screen), assembling them takes about one minute. The terminal is connected to the system by a single RS-232C cable that comes with the terminal. Both units plug into a standard wall outlet. If you have a printer, it connects to the back of the system unit and can be configured automatically the first time you turn on the system.

Once you connect and plug in these parts, switch them on and the computer begins a one-time-only self-check to confirm that the data on the hard disk arrived intact. The MD-11 then sets out to learn the software and hardware configuration you've established. This is a fairly long process, so the computer occasionally displays encouraging messages to let you know everything is okay.

THE CO-PILOT

When you turn on the MD-11, it first initializes and then goes directly into a program called Co-Pilot. Co-Pilot displays a hard-disk application-program menu (see photo 1). Pressing the number key that corresponds to an application program will cause Co-Pilot to immediately switch to the program and dis-

(continued)

John Heilborn is a writer whose company, Think Works, is located in Castro Valley, CA 94546.

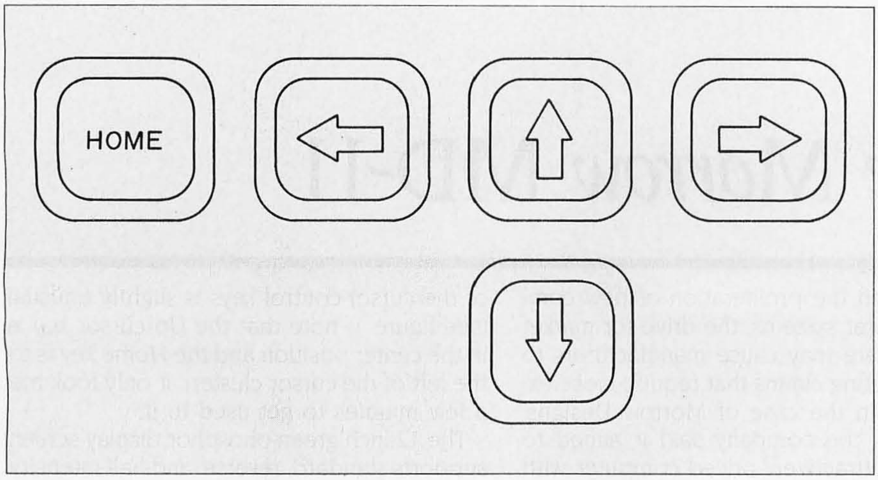


Figure 1: *Morrow arranged the cursor-control keys in what might be termed an inverted-modified diamond and placed them at the upper right of the keyboard with Help to the left of Home and Erase to the right of Right cursor.*

Table 1: *Not only is the cursor programmable (as shown here), but you can toggle the entire screen between standard and reverse video by invoking the Esc-K-0 and the Esc-K-1 commands, respectively.*

Cursor Programming Control Codes

Esc G 0	block, slow blink
Esc G 1	block, fast blink
Esc G 2	block, no blink
Esc G 3	underline, slow blink
Esc G 4	underline, fast blink
Esc G 5	underline, no blink
Esc G 6	no cursor

play the screen shown in photo 2. The program then takes over. After you terminate the application, Co-Pilot once again takes control, displaying the option menu.

CP/M Utilities

In addition to the eight application programs, Co-Pilot also gives you access to seven CP/M utilities and a training program. The CP/M utilities provide such standard housekeeping functions as formatting new disks, copying files, displaying the directory, and renaming or erasing files.

The Utility menu contains another feature of considerable merit—fundamental training in CP/M. If you enter item 8 from the Utility menu you can take a crash course on the operating system.

Customizing the System

When you first start up the system (either by turning it on or by hitting Reset) it initializes itself and then looks for a file called PROFILE.SUB. PROFILE.SUB is a text program that automatically loads its cargo of characters into the MD-11 just as if the characters had been entered from the keyboard. In this respect the MD-11 uses PROFILE.SUB as if it were a command buffer.

When the MD-11 is shipped from the factory it is set up to enter the Co-Pilot menu right after initialization. This is because Co-Pilot is in the PROFILE.SUB file, which contains the following information:

```
setdef *,a:|order=(com,sub)|
pilot go
```

The first line tells the MD-11 to set the search path for files on the hard disk; this line is best left unchanged. The second line specifies that after initialization the MD-11 will run the menu program called Pilot Go. If you modify PROFILE.SUB and change this entry to NW, the MD-11 will run the NewWord program every time it is initialized. If you delete the program name altogether, the MD-11 will go directly to the CP/M prompt after initialization. To test your changes, press Reset.

Because PROFILE.SUB actually enters characters into the MD-11, you can also set it up to enter the cursor and screen attributes at initialization.

IMS

Another way to predetermine the actions of the MD-11 is by using an IMS (In Memory Submit) file. An IMS can be entered directly from the keyboard, through a program, or from PROFILE.SUB (invoked automatically upon system initialization). The general form of an IMS file is:

```
A> IMS command string; command string ¦ command string
```

Note that the first and second commands are separated by a semicolon, while the second and third commands are separated by pipes (the vertical bar on the keyboard). The semicolon inserts a carriage return (<CR>) at the end of the command, and the pipes cause the MD-11 to hold the next command in memory until the next warm boot (i.e., ^C). This is handy because, for example, it lets you use the IMS to enter NewWord and then, after leaving NewWord, run a directory or set up new screen defaults. Without the pipes you would either have to enter a new IMS string or put the command characters into NewWord. When you execute an exit, most of the application programs will automatically cause the system to warm boot, thus activating the next IMS command, if there is one.

Programming the Function Keys

Another way you can customize your system is by redefining the function keys with the key program KEY.COM. To use this program, create a text file that defines the character string you want generated when you press a particular function key. This can be a single character or a string of characters.

Initially, the MD-11 key strings are defined by a file called DEFAULT.KEY. This file gives the function keys defini-

(continued)

AT A GLANCE

Name
Morrow MD-11 Hard-Disk Micro Decision

Manufacturer
Morrow Designs
600 McCormick Street
San Leandro, CA 94577
(415) 430-1970

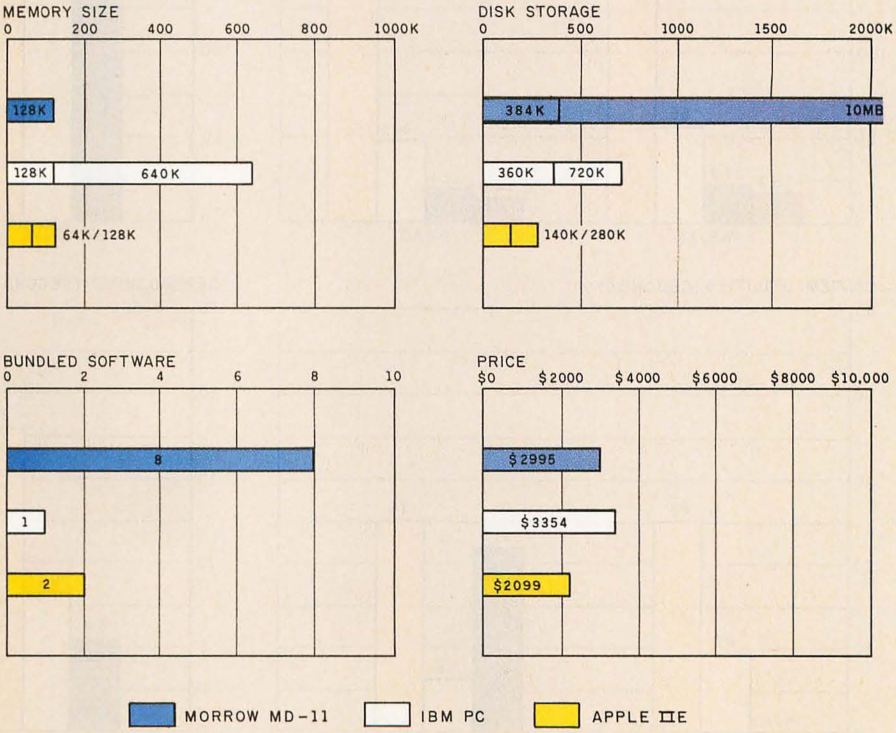
Components
System Box: 17 by 11½ by 5½ inches; 4-MHz Z80A; 128K bytes (bank switched); one floppy disk (384K); one hard disk (11 megabytes); three RS-232C ports; one high-speed RS-422 port; one Centronics-type parallel port.
Terminal: Keyboard—18 by 7 by 2½ inches; detachable with sculptured keys; 17 programmable keys including 9 function keys; separate numeric keypad and flattened-diamond-cursor pad.
Video Display—12-inch (diagonal) green-phosphor monochrome display, 80 columns by 24 lines.

Software
NewWord, Correct-It, SuperCalc, Personal Pearl, Quest, MBASIC, Pilot, Backfield, CP/M 3.0

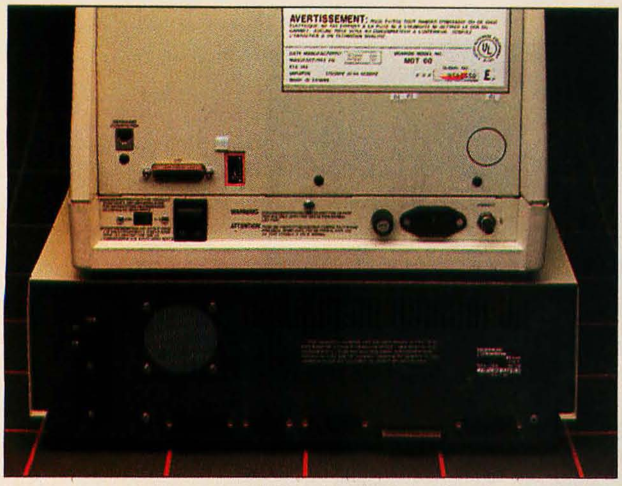
Options
Coprocessors:
MDCP88-128: 8088 coprocessor board with 128K bytes of RAM $499
MDCP88-256: 8088 coprocessor board with 256K bytes of RAM $699

Documentation
Nine manuals

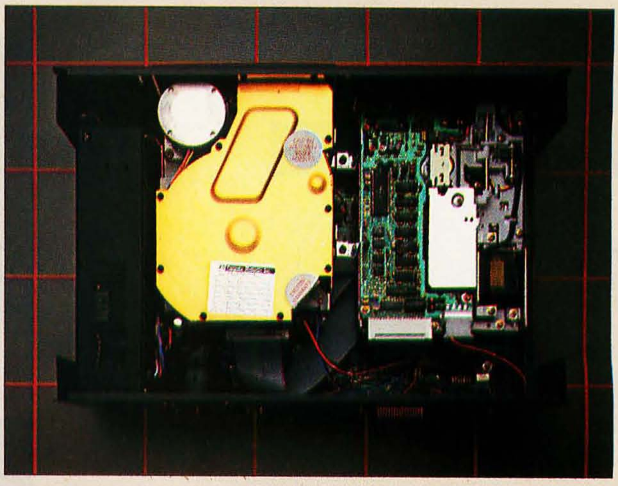
Price
Terminal, software, documentation $2995



The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity of a single disk drive for each system. The Bundled Software graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives; a monochrome monitor; graphics and color-display capability; a printer port and a serial port; 256K bytes of memory (64K for 8-bit systems); the standard operating systems for the computers being compared; and their standard BASIC interpreters.

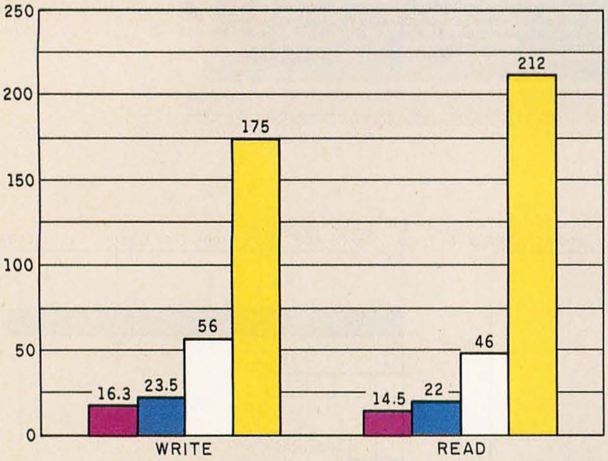


Rear of system unit reveals five I/O ports.

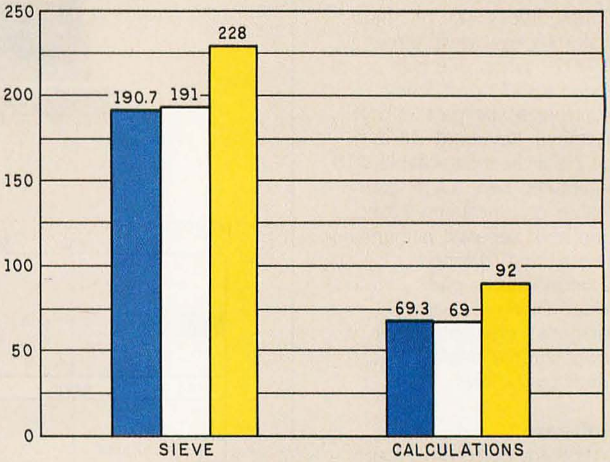


MD-11 *system unit incorporates hard- and floppy-disk drives.*

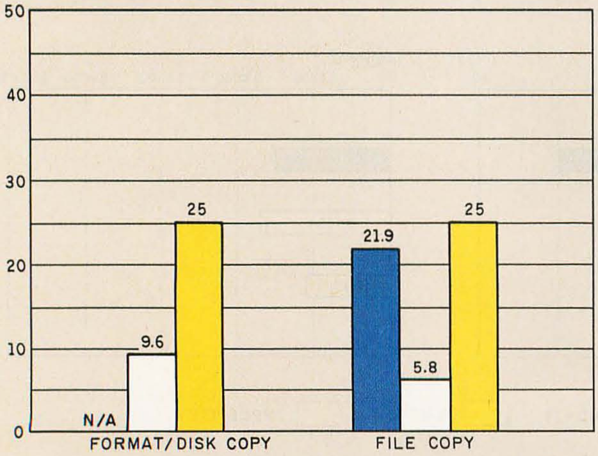
DISK ACCESS IN BASIC (SECONDS)



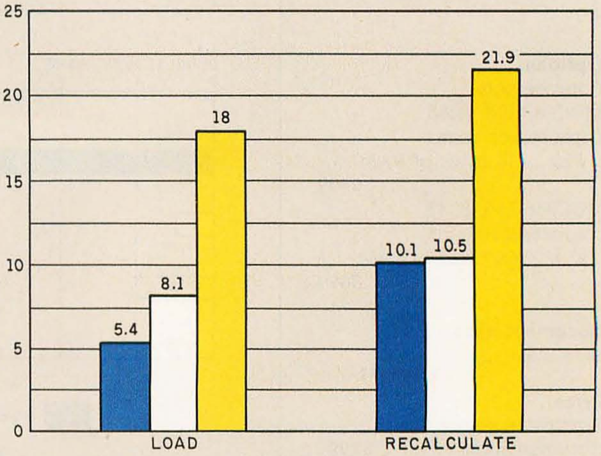
BASIC PERFORMANCE (SECONDS)



SYSTEM UTILITIES (SECONDS)



SPREADSHEET (SECONDS)



🟪 MORROW MD-11 HARD DISK
🟦 MORROW MD-11 FLOPPY DISK
☐ IBM PC
🟨 APPLE IIE

The Disk Access in BASIC graph shows how long it takes to write a 64K-byte sequential text file to both a blank floppy disk and a blank hard disk. Hard-disk tests were included for reading and writing in BASIC because the hard disk is a standard part of the Morrow configuration. No other benchmarks were performed using the hard disk since it would not affect their results. The Sieve column shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations column shows how long it takes to do 10,000 multiplication and division operations using single-precision numbers. The System Utilities graph does not include a column for format/disk copy because the Morrow has only one floppy-disk drive. The File Copy column shows how long it takes to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers took to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet program used was Microsoft Multiplan.

tions that work fairly well with most of the programs. In addition to these generic default settings, the MD-11 has custom key settings that work specifically with individual application programs. Some of these key programs are NW.KEY (for NewWord) and SC.KEY (for SuperCalc). To set up the custom keys for NewWord, enter KEY NW instead of just NW.

To change the function keys, simply enter NewWord (or any other text editor) and type a new character string for each of the function keys you need. Those that are not redefined retain their default definitions.

THE MORROW DISK CONTROLLER

The MD-11 has just one disk controller to handle both hard and floppy disks. Although it might seem like Morrow did this to cut the price of the system (possibly compromising performance in the process), this is not the case. The controller handles both floppy and hard drives with one set of circuitry and performs better than conventional dual-controller systems (see the discussion on benchmarks later in this article).

Morrow divided the controller into three operational sections (see figure 2). The Z80A microprocessor handles one of the sections, the ROM (read-only memory) takes care of the second, and some PALs (programmed array logic) and support circuitry handle the third.

When the disk controller is in floppy mode, the Z80A sends addresses and disk-instruction code directly to the ROM and the PALs. The Z80A-generated commands and the ROM-produced code (when the Z80A addresses it) control the floppy-disk drive.

As the controller reads data from the floppy disk, the data goes into a buffer and is transferred to its destination. Most disk controllers perform one extra memory transfer but the MD-11 saves time because it doesn't have to do this.

The hard disk moves data much more quickly than the floppy disk. To operate efficiently, the Z80A would have to generate control codes at speeds that exceed its capabilities. So, instead of the Z80A actually producing the codes, the MD-11 uses the ROM and the PALs in-combination when accessing the hard disk. To do this,the Z80A stops producing codes and simply produces addresses for the ROM. The ROM then produces the codes for the PALs and their support circuitry, which then operate the hard disk.

When the MD-11 transfers data, it reads it only once, which saves the time that would be lost using conventional disk controllers.

THE SOFTWARE

Morrow bundles eight application programs with the MD-11.

NEWWORD

NewWord is a word-processing program similar to WordStar in both form and function. However, there are a number of notable differences between them.

The UNERASE command cancels your last command. For example, if you deleted a line by mistake or rewrote a paragraph and found you liked it better before you rewrote it, you can undo the damage. UNERASE is also an easy way to move a small text block. For example, if you delete a line using ^Y, it will be taken from your document and placed in the unerase buffer. If you decide that you really wanted the line after all, you can press ^U and the line will be restored. Alternatively, you can position the cursor in a new location before you press ^U and the text will be placed there.

The video-display enhancements in NewWord let characters you program to be printed bold, underlined, or enhanced be displayed that way on the screen.

NewWord has automatic ruler lines, which means that whenever the program encounters a ruler line in text, that line automatically becomes the current ruler line when the cursor passes it.

NewWord generally is faster than WordStar (see the benchmarks on the "At a Glance" page) because it doesn't use overlays during text editing. NewWord overlays are special segments the program must retrieve from the disk each time it uses them.

Currently, NewWord does not have a column-move function but sources at Newstar Software Inc. (the publisher) indicate that this function should be available very soon.

CORRECT-IT

Most people occasionally misspell a word. Correct-It is designed to fix spelling mistakes in NewWord and most other word-processing program text files.

Correct-It looks up every word in your text file and compares it to one or both of its two dictionaries. Its first dictionary has 36,000 words. If Correct-It cannot find your word in its main dictionary, it looks at an auxiliary dictionary containing words that you have entered. Any words that do not appear in either dictionary will be noted. If you want to correct a word you can, or you can leave it unchanged.

SUPERCALC

SuperCalc is a popular spreadsheet program that has been around for a while. If you have not yet had a chance to use a spreadsheet program, you'll probably be struck by its visual similarity to manual spreadsheeting.

SuperCalc's display is set up to look like an accountant's worksheet. It has rows and columns that are divided into cells. It can contain more than 16,000 cells, each of which can reside in variable-width columns. Any of the cells can contain numerals, text, or a formula. If the cell contains text (such as a heading), the words will be displayed on the screen (or printed on the printer). Numbers will also be displayed; however, the numbers will be used to calculate values with the formulas that you insert in their respective cells. For example, let's say that you have a column of numbers. At the bottom of the column of numbers, you have a cell with the formula

```
SUM A1:A90
```

This would tell SuperCalc to place the sum of all the numbers in column A, rows 1 through 90, in the cell with this formula. If, after entering all this data, you find that you have made a few mistakes, all you have to do is correct them. The sum will be corrected automatically.

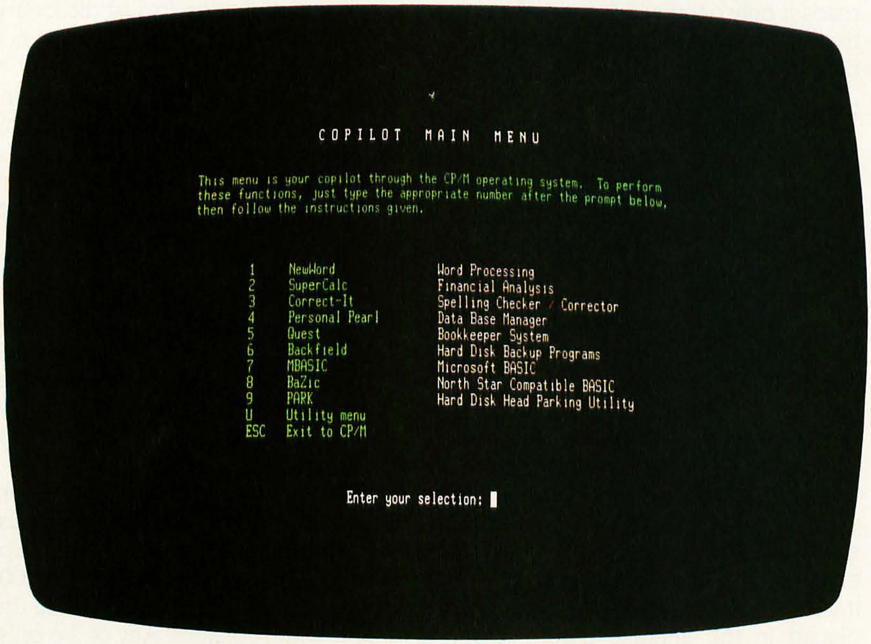
PERSONAL PEARL

Personal Pearl is a database-management program. With it, you can produce data-entry systems (using custom forms that you create) and design reports presenting data in almost any way you like.

Basically, Personal Pearl consists of four interrelated programs: Design

(continued)

Forms, to produce the data-entry system; Design Reports, which allows you to organize the data in your own custom forms; Enter Data, the data-entry routine; and Produce Reports, which puts your data into your custom forms and either displays it on the screen or prints it.



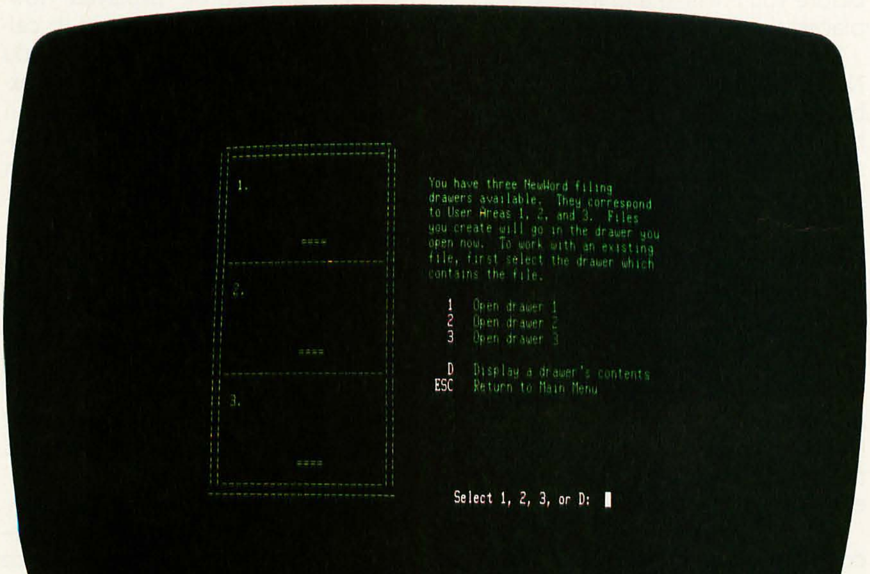
```
                    COPILOT  MAIN  MENU

This menu is your copilot through the CP/M operating system.  To perform
these functions, just type the appropriate number after the prompt below,
then follow the instructions given.

     1     NewWord              Word Processing
     2     SuperCalc            Financial Analysis
     3     Correct-It           Spelling Checker / Corrector
     4     Personal Pearl       Data Base Manager
     5     Quest                Bookkeeper System
     6     Backfield            Hard Disk Backup Programs
     7     MBASIC               Microsoft BASIC
     8     BaZic                North Star Compatible BASIC
     9     PARK                 Hard Disk Head Parking Utility
     U     Utility menu
     ESC   Exit to CP/M

                 Enter your selection: █
```

Photo 1: *The Co-Pilot menu provides you with access to eight application programs. Additional menu options direct you to* PARK *(hard-disk heads) and the* Utility *menu.*



```
You have three NewWord filing
drawers available.  They correspond
to User Areas 1, 2, and 3.  Files
you create will go in the drawer you
open now.  To work with an existing
file, first select the drawer which
contains the file.

   1    Open drawer 1
   2    Open drawer 2
   3    Open drawer 3

   D    Display a drawer's contents
  ESC   Return to Main Menu

        Select 1, 2, 3, or D: █
```

Photo 2: *Each of the application programs has an electronic filing cabinet associated with it. The drawers in each cabinet allow you to store different kinds of documents in different drawers or files.*

QUEST

The Quest bookkeeper system performs three bookkeeping functions. The first is accounts payable, which handles sales posting and journal, accounts receivable and reporting, and cash receipts posting and journal. The second is cash disbursements, which takes care of dispensed cash and checks, the cash disbursements journal, and vendor listings. Finally, the general-ledger function deals with trial balance reports, balance sheets, and income statements.

Quest also lets you produce checks directly from your data. To do this, however, you need specially printed checks.

As it comes with the MD-11, you can only use Quest for demonstration. To keep your books with it, you must send a $37.50 registration fee to Quest. They will send you a special code that allows you to fully access the system.

BACKFIELD

As reliable as hard disks are, it is still possible that something (such as a power failure) could damage your data. Therefore, it is advisable to back up your data frequently.

The only problem with this is that the MD-11 disk has a capacity of 11 megabytes (equal to more than 25 Morrow-format, double-sided double-density floppy disks). Therefore, it could be both time-consuming and expensive to back up the hard disk daily.

Fortunately, Morrow includes a program called Backfield as part of the MD-11 software package. Backfield stores data in compressed form, which makes it easier to back up the entire hard disk. And only the files that were modified since the last time are backed up; individual large files (such as databases) are copied on a one-by-one basis. Backfield uncompresses the compressed data before you use it. It also can store noncompressed data with the normal space requirements of standard-format data.

PROGRAMMING LANGUAGES

The MD-11 includes two very different programming languages: Pilot and Microsoft BASIC (MBASIC).

Unlike many of the more popular programming languages (such as MBASIC),

(continued)

O L Y M P I A

Before you pick a printer, make sure it's fully compatible with your computer. Make sure it's right for your software programs. Make sure it's flexible enough for the functions it must perform. And if the return on investment that you expect is durable construction, trouble-free performance and letter-quality printing, make sure it's Olympia.

Consider the Olympia printer portfolio: *Electronic Compact RO.* If you need an entry level printer, this is the one to consider. Compatible with every personal computer and low in price, it provides all the features needed for efficient day-to-day performance. *Electronic Compact 2.* Combines excellent print quality with the versatility of a built-in typewriter keyboard. Perfect for business and personal use. *ESW102.* Excellent value in a medium-speed office printer, with broad flexibility for forms and letter formats. *ESW3000.* Your best investment in a fully featured, high-speed printer for a demanding work load. *Electronic Compact NP.* Our dot-matrix printer offers speeds of up to 165 CPS, as well as a correspondence mode, for a surprisingly low investment.

With Olympia, you can invest in the printer that's exactly right for you.

Before you invest in printers, make sure you consider Olympia.

Send for our booklet: "Olympia takes the mystery out of selecting a printer." Also request product information on any or all of these excellent printers.

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☐ ESW102
☐ ESW 3000
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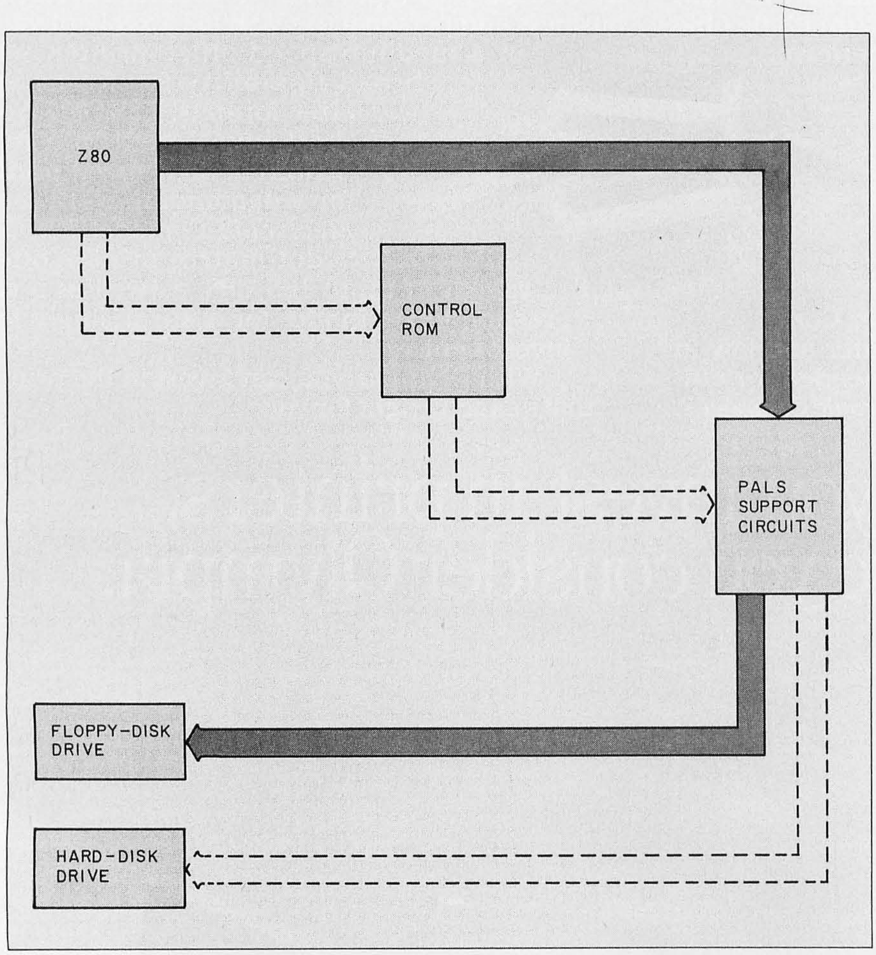

Figure 2: *Central to its bid for higher speeds is the MD-11's controller, which, among other things, reduces the number of memory transfers required to deliver the data to its destination.*

Listing 1: *This Pilot program example demonstrates that the language is dialogue oriented and, as such, is useful in interactive-text programs.*

```
T:                          This is a Pilot Example
T: ----------------------------------------------------------------
T:
T:
T: In this example you will be able to choose one of three items
T:
T: The items are:
T:
T: 1) Bananas
T: 2) Apples
T: 3) Oranges
T:
T:
T: The program will give you the price of the item you select.
A:
M: 1
TY: Bananas cost 95 cents a pound.
M: 2
TY: Apples cost 59 cents a pound
M: 3
TY: Oranges cost 79 cents a pound
END
```

Pilot is a dialogue-oriented language. As such, it makes it easy to produce programs that use a lot of interactive text; for example, the Co-Pilot menu program in the MD-11 was written in Pilot. See listing 1 for a simple Pilot program. The command T: tells the computer to "type" the line that follows on the display. It is similar to the PRINT command in BASIC.

The A: following the "typed" lines tells the computer to wait for some kind of "answer" from the keyboard. The answer must be followed by a <CR> and is similar to the INPUT command in BASIC.

M: tells the computer to "match" the keyboard entry with the preset response and TY: tells the computer to "type" the line that follows if the response matched the preset value in the M: command. Together these work a bit like the IF. . .THEN combination in BASIC.

Pilot originally was designed to be a teaching aid. Its interactive organization makes it ideal for question-and-answer routines. Pilot works well for this kind of routine because, once the program has been written, it is easy to change questions and answers while leaving the program otherwise unchanged.

BENCHMARKS

These tests were designed by BYTE to determine how quickly different computers perform different tasks. The benchmarks are divided into three sections: BASIC benchmarks, word-processing benchmarks, and spreadsheet benchmarks. The "standard" computer against which the test results are compared is the IBM PC. (In tests that use the MD-11's hard disk, the IBM PC XT is used as the standard.)

BASIC BENCHMARKS

These four tests are represented graphically on the "At a Glance" page (page 328). For the program listings, see "The Chameleon Plus," by Rich Krajewski, June BYTE, page 327.

Writing to disk: This test creates a 64K-byte random-access file and measures how long it takes to write the file onto a blank formatted floppy disk in 128-byte blocks. I also did this test with the hard disk, which contained roughly 1

(continued)

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Table 2: *Results of BYTE benchmark tests indicate that the MD-11 does well in disk-access tests while recording slower times when driving a display.* (*All results are in seconds*).

BASIC Tests	MD-11	IBM PC/PC XT
Read/Write		
Floppy-disk write	23.5	28.7
Floppy-disk read	22.0	32.1
Hard-disk write	16.3	8.0
Hard-disk read	14.5	8.0
Calculations		
Single-precision	69.3	69.2
Sieve of Eratosthenes	190.7	158.3
Spreadsheet Tests		
	SuperCalc	Multiplan
Load	5.4	7.2
Recalculate	10.1	6.2
Word-Processing Tests (on hard disk)		
	NewWord	WordStar
Disk Access		
Load file	3.3	9.9
Save file	6.2	24.2
File Operations		
Search	4.0	10.5
Scroll	83.2	41.2

megabyte of data. To run this on the hard disk, I changed the disk-drive designation from B to A.

Reading from disk: In this test, I read the data that was written in the previous test. The computer reads the 64K bytes in 128-byte blocks. As with the first test, I also ran this on the hard disk. To do this, I again changed the disk-drive designation from B to A.

Calculating single-precision numbers: This test measures how quickly the computer can perform two multiplications and two divisions 5000 times. The test also shows how much error (if any) is introduced by the system.

Sieve of Eratosthenes: The last BASIC test determines how long it takes the computer to perform one iteration of the Sieve of Eratosthenes prime-number program.

WORD-PROCESSING BENCHMARKS

I did the word-processing benchmarks with a standard document consisting of 40 paragraphs. Each paragraph contained 10 sentences of 10 words each: "One two three four five six seven eight nine ten." This produces a 4000-word document. The tests performed are: loading a document, saving a document, searching for a word, and scrolling. These tests were run on NewWord.

SPREADSHEET BENCHMARKS

There are only two spreadsheet benchmarks. The first determines how long it takes to load the standard spreadsheet, and the other measures how long it takes to recalculate the entire spreadsheet.

The standard spreadsheet has a 25-cell by 25-cell matrix. Each cell is programmed to equal 1.001 times the cell to its left. The values for the first column are calculated on the 25th cell in the row above, and the first cell in row 1 contains a 1.

The Morrow MD-11 is generally a smooth, responsive computer.

THE NUMBERS

The results of these benchmarks are listed in table 2. As you can see, the MD-11 was faster than the IBM PC and/or the PC XT about half the time. The Morrow recorded its best results in the word-processing tests that required disk access. The better access times may be due to the design of the MD-11's disk controller.

I found that the MD-11 was significantly slower in the document-scroll test. This probably is due to the fact that the IBM PC drives the integral video display through a parallel port while the MD-11 sends data to a stand-alone terminal through a serial RS-232C port.

CONCLUSIONS

The MD-11 is generally a smooth, responsive computer and most of the functions I tested in the benchmarks (such as saving and loading) are fast enough that I rarely noticed them when I was using the system.

Unlike systems such as the IBM PC (which are typically sold à la carte), the MD-11 is a complete computer system including 128K bytes of RAM, a 384K-byte double-density double-sided floppy-disk drive, an 11-megabyte hard disk, and a sharp, green-phosphor terminal. The bundled software includes a word processor and spelling-correction program, a spreadsheet program, a database-management program, a bookkeeping demonstration, two programming languages, and a hard-disk copy program in addition to the operating system.

The system is customized easily using the programmable keyboard, system-configurable program functions, and self-programmed start-up routines. With these and the Co-Pilot menu system, the MD-11 is a powerful yet simple-to-use computer, definitely worth a second look. ■

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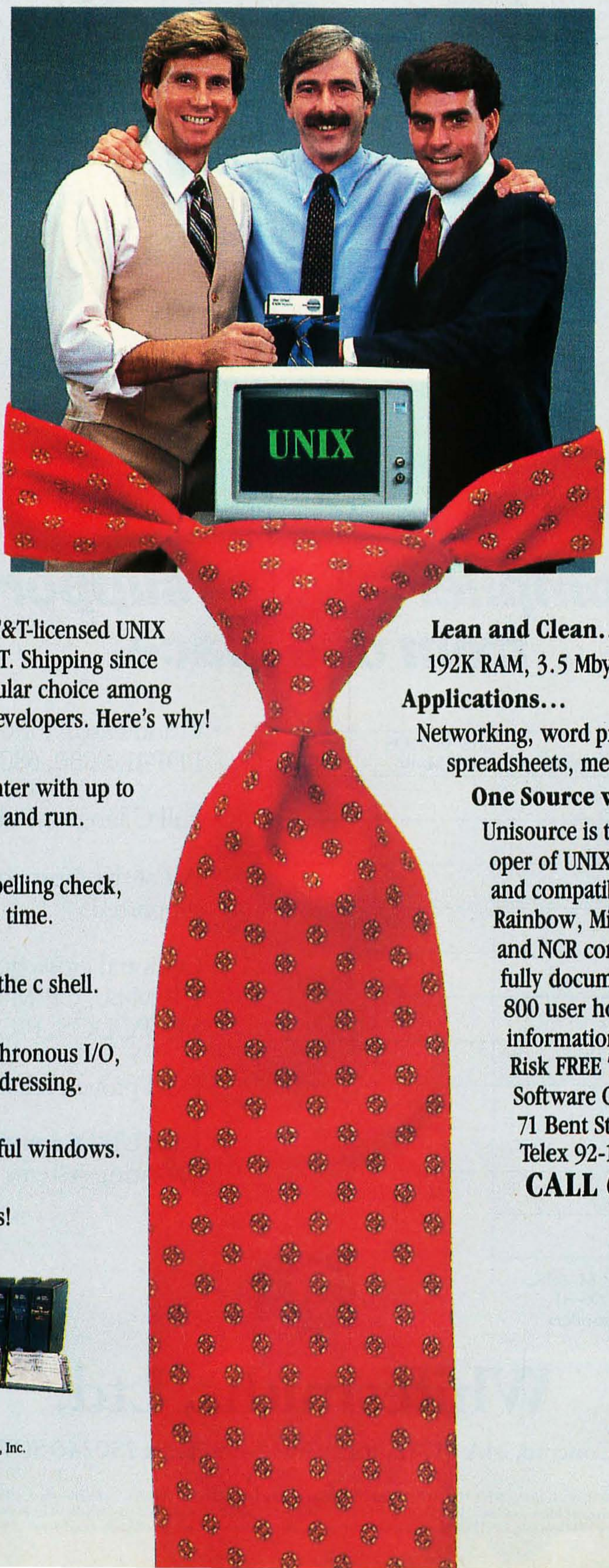

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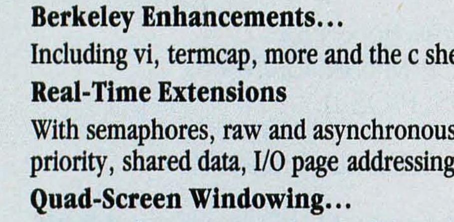

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HARDWARE REVIEW

Five Voice Synthesizers

Linear predictive coding ICs provide quality output

BY GEORGE H. SMITH

Linear predictive coding (LPC) speech synthesizers have been around for years, but they haven't really penetrated our society yet. Many computer professionals don't understand what they're about or how to use them. In this article, I'll discuss the advantages and problems of using LPC synthesizers and compare the architecture, strengths, and weaknesses of five LPC synthesizer ICs (integrated circuits) manufactured by U.S. companies. I've distilled information gleaned during the past two years while implementing hardware and software that encode and synthesize voice for these devices.

I have neglected Japanese synthesizer manufacturers such as NEC, Hitachi, and Mitsubishi in this article because I wasn't able to get enough information about them to actually code voice for them, despite efforts to do so. I also omitted the Texas Instruments (TI) TMS 320 signal-processing chip; although it can do speech synthesis, it belongs in a different ball game. Even though its cost will drop from the current $150, it requires a separate digital-to-analog (D/A) converter, so the cost of this device will remain substantially higher than that of fully integrated synthesizer chips.

If you aren't familiar with LPC synthesizers, study figure 1, which shows how synthesized speech is made by stringing together short, 20- to 30-millisecond (ms) "frames" of sound generated by a simplified electronic model of human-voice production. For a general introduction to voice synthesis, see "Speech and Voice Synthesis" on page 340.

For each synthesizer reviewed, I'll describe the frame length, the coefficient precision, the method of voice-data input, the audio buffering and low-pass filter requirements, and the typical data rate.

Frame length: This is the number of times per second that the synthesizer coefficients are updated. Ideally, a synthesizer could accept new coefficients at very short intervals to track quickly varying sounds (with a higher data rate) or could be told to use the same coefficients for a longer time to keep the bit rate low when the speech sound stays the same.

Coefficient precision: This is the number of bits used to encode the various parameters. Having more bits to describe the filter coefficients sometimes can improve the speech quality at the cost of higher data rate.

Method of voice-data input: Three important questions relate to this topic. Does the synthesizer have on-chip ROM (read-only memory)? Does it need a special voice memory? Can a microprocessor send data directly to it?

Audio buffering and low-pass filter requirements: To avoid a mechanical sound, speech reconstructed from digital data must be smoothed with an analog filter. Some devices provide this on the chip.

Typical data rate: The data rate for any given chip can vary widely depending on, for example, how many coefficients you use and how much editing time you spend on data compaction. The "typical" rate reflects editing for intelligible speech without optimizing for throughput.

THE SP-250

The SP-250 from General Instrument (GI) was one of the early synthesizer chips. Its vocal-tract filter is different from most of the other devices in that it uses a series of six cascaded simple digital filters, with each of these "second-order sections" specifying one resonance, or formant, of the voice sound.

One appealing aspect of this filter structure is that you can give an intuitive meaning to each of the parameters sent to the filter. Two bytes specify each filter section: one corresponds to the formant frequency, while the other corresponds to the formant's bandwidth and amplitude. This intuitive meaning might be useful for implementing special effects or for reducing the basic data rate by specially coding the frequency and formant values (which often change fairly slowly) and expand-

(continued)

George H. Smith (POB 1364, Palo Alto, CA 94302) is the owner of Adisa Corporation. Adisa provides boards and software for encoding LPC parameters for those chips reviewed in this article. For relaxation, Smith enjoys picking Earl Scruggs tunes on a Gibson five-string banjo.

ing these coded values to their full values before sending them to the synthesizer.

Each coefficient in this device can be specified with 8 bits of precision, which is more than adequate for most speech. Coefficients are updated after each pitch period, so the frame rate and the final data rate depend on the number of filter sections you use, the pitch period, and how many times you repeat a given set of coefficients. As with most synthesizers, you can trade off bit rate for quality by repeating the same frame several times instead of tracking slow changes in the sounds produced. Sometimes this can have a beneficial effect for the SP-250—eliminating some small variations in a long "e" sound, for example, can make it a lot smoother. Carried to extremes, however, the result is speech that sounds very unnatural. The bit rate for the SP-250 is 350 to 600 bytes per second, depending on how many coefficients you use and how fancy you get in coding the coefficients. You can compress below this rate but the speech quality suffers.

The audio output for this chip is not an ordinary D/A converter output: it's a pulse-width-modulated, transistor-transistor logic (TTL) signal (see figure 2). This signal must be low-pass filtered and sent through a power-amplifier IC before driving a speaker, but a simple RC (resistor/capacitor) filter and inexpensive LM386 IC amplifier are adequate for this purpose.

Interfacing a microprocessor to the SP-250 is simple: connect the eight Data lines, a Data Request strobe line, a Reset line, and let the SP-250 Data Request output interrupt your microprocessor when more data is needed. Due to setup and hold times on the Data lines, you'll need to latch data from the microprocessor to the SP-250, then generate the 1.5-μs (microsecond) Data Request strobe either by toggling 1 bit in software or by using a one-shot multivibrator.

One nice feature of this device is the way it repeats the last sound it was making if new data is not supplied when requested. Consequently, if your processor is busy (servicing another interrupt, for example) and is slow getting data to the chip, the SP-250 just stretches a sound for an unnoticeably longer time instead of stopping altogether (as some other chips do). Unless you have a 3.12-MHz signal to drive the external clock input, the device requires a physically large 3.12-MHz crystal to provide its basic timing.

The SP-250 can sound quite good if you choose the talker very carefully, you don't try to get the bit rate too low, and you are willing to put considerable effort into editing the speech. Because its fundamental sampling rate is 10 kHz rather than the 8 kHz for most other chips, the SP-250 can get marginally brighter "s" sounds, but other advantages of this higher rate are hard to identify. The chip's main advantages are low cost, simple output buffering circuit, and a variable frame size that supports good tracking for quickly varying speech sounds at voiced-unvoiced transitions.

THE SP-256

GI's SP-256 evolved from the SP-250. Although the internal speech-synthesis circuitry is identical to the SP-250, there are significant differences.

The SP-256 has an internal ROM that you can use for a custom vocabulary (if you're making tens of thousands of your widget). Of greater interest to less ambitious users is GI's version of the chip that has a phoneme library on this ROM.

Beyond the speech-synthesis circuits, this chip has a simple front-end micro-

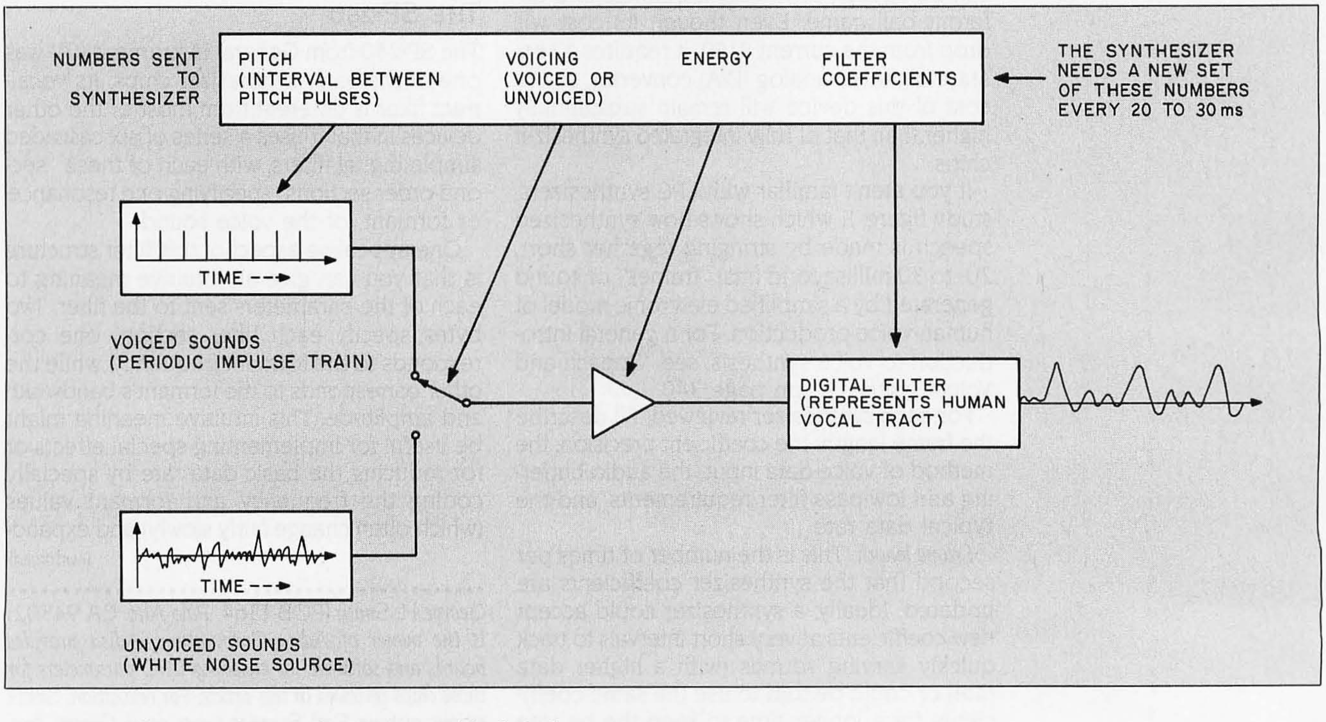

Figure 1: A *linear predictive coding* (LPC) *model of the human voice.*

processor controller. The controller enables you to embed commands in the data; for example, you can use subroutines to let several different phrases use the same word. The controller also unpacks compressed forms of the data; i.e., you can specify that some coefficients will be presented with fewer bits or that "differential" coefficient data will be sent (use the previous frame's coefficients but add the following numbers to them first).

The SP-256 can get voice data only from its internal ROM or from a special, external (serial) voice ROM. You can also use external byte-wide ROM or RAM, but you'll need GI's special (40-pin) parallel-to-serial adapter chip to do this. A microprocessor can't send voice data directly to the device—it sends starting addresses to the chip, and the synthesizer then goes to its own internal or off-chip local memory to begin reading voice data.

A standby pin puts the chip in a power-down mode, which cuts its power requirements.

Besides these differences, the previous comments about the SP-250 apply to the SP-256.

I believe that GI intends for this chip to be used in cost-sensitive applications that have limited and unchanging vocabularies.

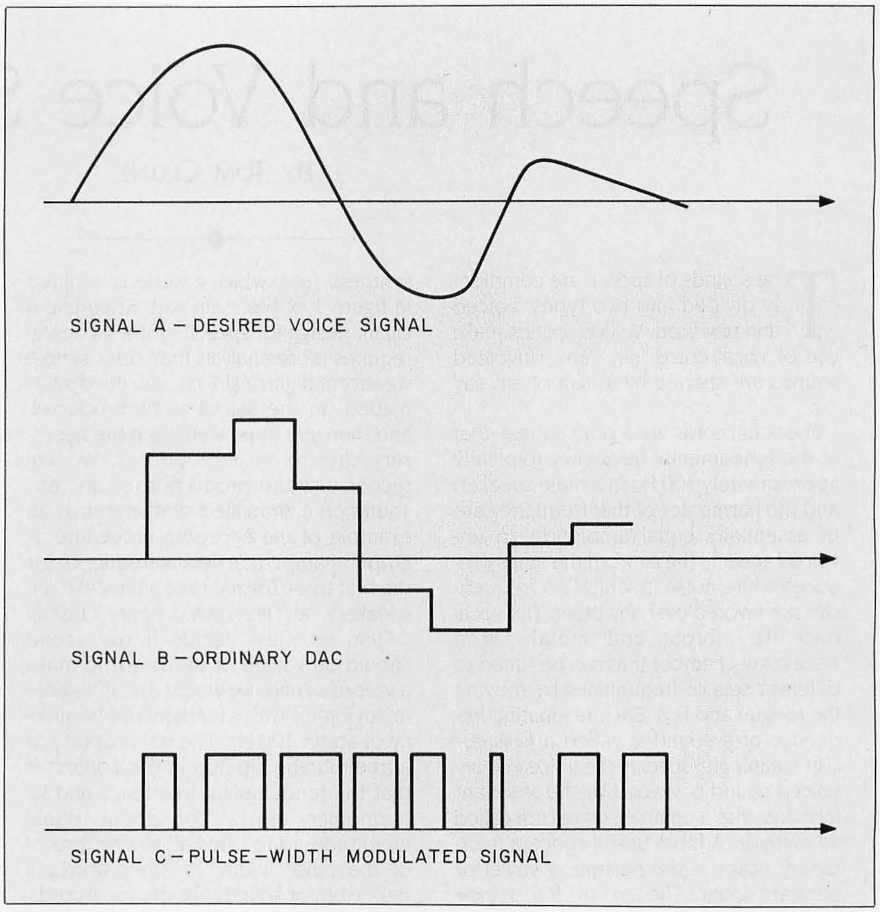

Figure 2: *Two alternate forms of synthesizer output that can be used to reproduce signal* A: D/A *converter (signal* B), *in which an amplitude proportional to the voice signal at some time is held constant until the next sampling time, and pulse-width modulation (signal* C), *in which the pulse width is proportional to the voice signal at the sampling time. When sent through a low-pass filter, both signals get smoothed into the desired voice signal.*

THE TMS 5220

With the introduction of the Speak and Spell toy, TI established its reputation in speech synthesis and its commitment to this technology. A series of speech-synthesis products has sprung from TI's initial synthesizer, culminating in the TMS 5220 and, soon, the TMS 5220A.

The 5220 uses the *lattice* form of digital filter to implement the vocal tract model. Unlike the coefficients for the SP-250, the "reflection" coefficients, or "K" coefficients, that control this filter don't lend themselves to a compact and useful interpretation. This type of filter does have some useful implications, however; the reflection coefficients can be interpolated from one frame to the next to ensure a smooth transition between frames. The TMS 5220 interpolates automatically, resulting in smooth voice quality.

The chip's judicious balance of frame rate and coefficient precision produces good speech quality at about 200 bytes per second (or less if you want to invest the editing time). The frame rate for the 5220 is fixed: coefficients are updated every 25 ms unless you run the chip faster than an 8-kHz sampling rate, and there's no real advantage to doing so. The pitch parameter for the device is efficiently coded on a sort of logarithmic scale, with 63 values covering a range of 50 to 500 Hz. For voiced sounds, 39 bits are distributed among the 10 filter coefficients with K1 getting 5 bits and K8 through K10 getting only 3 bits. Omitting the last six K parameters for unvoiced sounds and using a special code for silent frames reduces the average data rate. Also, when the voice sound isn't changing, a "repeat" bit can be set to tell the chip to update only the pitch and energy parameters and use the previous frame's filter coefficients.

The 5220 contains an 8-bit D/A converter, and the output must be low-pass filtered and amplified. For the filter, TI recommends a third-order low-pass filter implemented with a quad op-amp, 12 resistors, and 3 capacitors.

Connecting to a microprocessor is complicated by two things. First, the chip is much slower than most microprocessors, so data and strobes must be latched. Second, to read all the status available from the chip, you need to implement a bidirectional data interface; unless you use an LSI (large-scale integration) parallel peripheral interface chip like the MC6821 or Intel 8255, this can get rather messy.

A few words of caution: TI chose to

(continued)

Speech and Voice Synthesis

BY TOM CLUNE

The sounds of speech are commonly divided into two types: voiced and unvoiced. Voiced sounds make use of vocal cords: say "ah." Unvoiced sounds are shaped by a rush of air: say "sh."

The vocal cords are a buzz source; that is, the fundamental frequency (typically approximately 100 Hz in a male speaker) and the harmonics of that frequency are of essentially equal amplitude. In unvoiced speech, the air from the lungs produces white noise in which no frequencies are favored over any other. The vocal tract (i.e., throat and mouth) is a resonating chamber that can be tuned to different sets of frequencies by moving the tongue and lips. Each resonating frequency of a sound is called a *formant*.

In meaningful speech, the voiced or unvoiced sound is shaped by the resonant formants into a complex waveform called an *allophone*. A more useful concept in ordinary usage is the *phoneme*, a vowel or constant sound. The "oy" in "foil," for example, is a single phoneme composed of more than one allophone.

Essentially, there are two approaches to synthesized speech. The first approach, waveform digitization, saves information on the waveform itself (i.e., voltage levels at any given time). We collect the synthesizing data with an A/D (analog-to-digital) converter and reconstruct the sound with a D/A (digital-to-analog) converter. Since audible sound includes components up to about 20 kHz, the amount of data collected can be problematically large. A variety of data-compression techniques can be used to reduce the amount of digitized data. These techniques generally involve either storing only the change in signal level between sampling intervals or using a transform of the signal. As compression techniques get more sophisticated, they tend to become more costly and difficult to use.

The second approach to speech synthesis stores the design of the circuitry needed to produce speech-like sounds rather than the speech waveform information itself. Linear predictive coding (LPC) is of this type. The model of speech synthesis from which it works is outlined in figure 1 of the main text. Encoding a circuit design for speech synthesis clearly requires more analysis than does simple waveform digitizing. First, you need information on the sound to be produced, and then you must sketch out the necessary circuitry to reproduce it. We will reconstruct the production of an "ah" sound on a simplified synthesizer as an example of the encoding procedure. A graph of amplitude versus frequency for the first three formants of a typical male speaker's "ah" is shown in figure 3 below.

First we must decide if the sound should be voiced or unvoiced. To make a voiced sound, we would use an astable multivibrator with a fundamental frequency of about 100 Hz. The key property of a free-running flip-flop in this context is that the fundamental frequency and its harmonics are all of about equal amplitude up to one-half the reciprocal of the pulse width. In other words, a multivibrator sounds like the vocal cords. For unvoiced speech, we could feed the output of a random-number generator into a D/A converter.

For the "ah" sound, we select voiced speech. Next, we must determine the design of the three resonators, or filters. Assume that we are using simple LC (inductance-capacitance) circuits separated by isolation amplifiers to avoid overloading a stage. The output of one filter will be the input of the next. We see from figure 3 that we want the three stages to resonate at 750, 1100, and 2450 Hz. If each stage has a 1-Henry inductor, we solve the equation $f = 1/2\pi\sqrt{LC}$ to find the values of the three capacitors (0.045, 0.021, and 0.004 μF, respectively).

Figure 3: *A graphic representation of the first three formants of "ah" as pronounced by a typical male speaker.*

We should consider one more complication. When we say that an LC circuit resonates at 750 Hz, we mean that there will be the least attenuation (loss of amplitude) for a 750-Hz signal, but signals of 740 Hz, for example, will also pass through the circuit to some extent. As the input frequency gets further away from 750 Hz, the attenuation increases. The frequency above or below the resonant frequency where the amplitude is halved is the filter's cutoff frequency. The difference in Hertz between the high and low cutoff frequencies is the bandpass of the filter.

Looking again at the figure, we see that we'd like to be able to select the bandwidth for our three filter stages. Let us suppose that we want a bandwidth of 50 Hz at stage one, 100 Hz at stage two, and 250 Hz at stage three. If we place a variable resistor in series with the components of each filter, we can control the bandpass in a straightforward way. For a series RLC (resistance-inductance-capacitance) circuit, the bandwidth in Hertz is just R/L (resistance to inductance). Thus, the resistor in stage one would be 50 ohms, in stage two 100 ohms, and in stage three 250 ohms. Increasing the bandpass of a filter also increases the damping (attenuation), so we would need to be able to adjust the gain for each filter segment to complete the synthesizer design. However, let's ignore this problem and consider the synthesizer complete.

The information we need to store is whether the sound is voiced and what the values of the capacitors and resistances are. If we output a stream of such circuit-design information to the right circuitry, we could produce phonemic speech. But it sounds choppy and mechanical because the sound is discontinuous. LPC

smooths the speech by interpolating values between one phoneme's circuit and the next, gliding between sounds for more natural speech.

Clearly, if we had to construct each sound in the way I have just described, we would spend months constructing a simple sentence. But speech-encoding equipment and services that identify the circuit parameters are available commercially (see the box on page 346). Note that each LPC synthesizer manufacturer's product requires its own encoding algorithm. Not every company supports each of the chips discussed in the main article.

Commercial support for voice development comes in three forms: off-the-shelf vocabulary ROM (read-only memory) chips, studio parameter-encoding services, and hardware for do-it-yourself voice encoding. The least expensive option is off-the-shelf ROMs. However, the vocabulary available is limited and the quality of voice reproduction suffers because the unit of encoding is the word rather than the phrase or sentence. In well-defined contexts, however, the economy of ROMs may make them the most attractive option.

Parameter-encoding services provide the highest-quality speech with minimal effort, but this can be rather expensive when encoding a lot of speech (approximately $100 per second). However, if the length of the speech to be encoded is less than a couple of minutes, this approach may prove cost-effective.

Buying the hardware (priced from $2000 to $20,000) and encoding the speech parameters yourself involves the most effort. Besides learning to use the hardware, you must develop a good ear for speech editing. For example, if the voiced-to-unvoiced transition in the word "watch" is misplaced, the "t" becomes inaudible. Nonetheless, this option offers the greatest flexibility. Vocabulary choices that looked good on paper but don't work in practice can be changed with minimal additional cost.

Tom Clune is a BYTE *technical editor. He can be contacted at* POB 372, *Hancock,* NH 03449.

spice our lives with variety by numbering its Data lines with D0 as the *most* significant bit. You'll probably forget this minor detail, but you were warned.

The 5220 can address special serial memories that TI manufactures, letting the microprocessor tell the chip: "Start talking, and interrupt me when you hit a stop code (energy=15)." Fortunately, you also can send voice data directly to the chip from the microprocessor, so you aren't limited to the words that TI chooses to put in its special masked ROMs. To relax the timing problems of getting voice data into the device, an on-chip 128-bit first-in/first-out (FIFO) buffer is provided. When this FIFO is half empty, the INT output is asserted. If your microprocessor can't get more data to the chip before the buffer is empty, the chip stops talking and, if you don't detect the 5220's idle state, subsequent data sent to the chip is misinterpreted, generating squeaks and "raspberry" noises. Since you have at least 25 ms (and probably more) to get the data out after INT is asserted, you probably won't have to worry about this.

Data formatted for the 5220 does not end with frames neatly separated by byte boundaries; a new frame can start on any bit within a byte.

Two special aspects of this chip should be noted. First, due to the limited precision of the digital filter on the chip, some voiced sounds seem very fuzzy if the energy is too low. You can solve this by editing the energy for these frames: often just increasing the energy eliminates this quantization noise. Other times, you'll do better to just eliminate the fuzzy frames by setting the energy to zero.

The second special problem of the device is that it tends to make low-level noises during zero-energy frames unless you precede the zero-energy frames with a special low-energy voiced frame that lets the filter state settle. These so-called limit cycle oscillations are insidious: they won't necessarily appear all the time, and they can sometimes occur even if the special "quiet" frame is used. In this case, lowering the energy of the preceding frame or inserting two special "quiet" frames generally solves the problem.

It would be nice if the chip used modes with more precision in the coefficients and shorter frames to get better voice quality over a broader range of talkers. However, the 5220 provides a good compromise between bit rate and speech quality. It's currently a popular synthesis chip and can produce smooth, high-quality synthesized speech at 150 to 200 bytes per second.

THE S3620

American Microsystems Inc. (AMI) makes both a male and a female talker chip. By tailoring the coefficient lookup tables for different types of talkers, the range of each parameter is smaller, so fewer bits are needed to code each frame. This lets you have more frames per second at a given data rate, which enables the synthesizer to track changes in the voice sounds more accurately.

Beyond providing male and female chips, AMI has done several other things differently. First, the S3620 is a CMOS (complementary metal-oxide semiconductor) device, so the chip itself doesn't consume much power. When it's not talking, it automatically goes into a power-down mode, dropping the power consumption to almost nothing.

Second, AMI uses "switched-capacitor" technology to implement the vocal tract filter instead of a digital filter like most other manufacturers use. This lets AMI include a low-pass output filter on chip (using the same switched-capacitor technique), minimizing the number of external parts. With its modest power amplifier, the S3620 can connect directly to a small speaker to provide 30 milliwatts (mW) of audio output.

The frame rate for this device is fixed at 20 ms. Like TI's 5220, this chip incorporates a lattice filter structure. Coefficients are interpolated between frames. The chip can handle only 16 different pitch values, and the filter coefficients get 30 bits per frame for voiced sounds (versus 39 bits per frame on the 5220). The total bit count for voiced frames is 40 bits, an even 5 bytes. Bits are saved by using only four filter coefficients and omitting pitch for unvoiced frames, and by having the synthesizer repeat the previous frame's filter coefficients. The maximum data rate for all voiced frames is, consequently, 250 bytes per second; an average rate of 150 to 175 bytes per second is typical.

The S3620 control-signal interface is

(continued)

Table 1: A *comparison of features for the five* LPC *synthesizer chips.*

Manufacturer	AMI	GI	GI	GI	TI
Name	S3620	SP-250	SP-256	SP-1000	TMS 5220
Package (DIP)	22-pin	28-pin	28-pin	28-pin	28-pin
Power supplies	between 5 and 8V at 25 mA	5V, 75 mA	5V, 90 mA	5V, 100 mA	+5V, 5 mA −5V, 35 mA
Low-power (standby) mode?	yes, 100 μA	no	yes, 21 mA	no	no
Filter type	lattice	2nd-order sections	same as SP-250	lattice	lattice
Number of filter coefficients	10	12	same as SP-250	10	10
Number of bits for filter coefficients	30	96	same as SP-250	90	45
Number of pitch levels	16	255	same as SP-250	255	63
Frame size	20 ms	one pitch period	same as SP-250	one pitch period	25 (to 20) ms
Bit rate (bytes/ second) maximum	250	700	same as SP-250	650	250 (312)
typical	175	250	same as SP-250	depends on packing technique	200
On-chip low-pass filter?	yes	no	same as SP-250	no	no
On-chip power amp?	yes, 30 mW	no	same as SP-250	no	no
Sampling rate	8 kHz	10 kHz	same as SP-250	programmable	8 kHz (to 10 kHz)
Price per chip (100 quantity)	$17.20	$5.53	$7.60	$16.00	$13.50
Special features	CMOS, switched-capacitor filter technology, separate male and female talker versions	PWM output	PWM output, on-chip phoneme library, special on-chip controller (see text)	PWM, feature estimation for voice recognition	popular

optimized for the 68XX class of microprocessors. If you're interfacing to another microprocessor, you may want to latch the eight data inputs to the chip before you issue the data strobe in order to meet the 400-nanosecond (ns) data hold time relative to the trailing edge of the 1-μs (minimum) write strobe. The device comes in a 22-pin package and derives its timing from a 640-Hz ceramic resonator. These resonators are cheap if you buy oodles of them, but they're pretty expensive if you want just a few.

It's important in your design to ensure that the strobe to the chip is held inactive (high) immediately when power is turned on. If it's not high when the chip's oscillator starts ticking, the chip will get hung up.

Also, this chip doesn't have an onboard FIFO buffer like the 5220—when the S3620 signals that it needs data, your microprocessor must provide the data within 100 μs or the synthesizer will turn itself off. If this happens, you will probably get a couple frames of weird sounds until the S3620 misinterprets some data as a stop code, stops issuing data requests, and hangs your system.

Since the chip generates a slight tick when it enters or leaves its power-down state, your software driver should provide several frames of silence before and after each utterance.

Unless you're driving an earphone, you'll probably want to provide an external power amplifier to drive a loudspeaker harder than the 30 mW that the chip provides; even AMI provides an LM386 on its evaluation board.

AMI also makes the S3610, which includes a 20k-bit on-chip data ROM for accessing up to 32 different utterances with no external memory. This chip was obviously designed for low-cost, mass-distribution applications that have a limited and fixed vocabulary.

The S3620 also is probably targeted primarily for product applications that don't involve many voice-data updates. It's a slightly less general-purpose device than others. You must choose between male and female talkers and, because there are so few bits per frame for the pitch and filter coefficients, you need to take more care in selecting a talker. To add voice output to consumer products, though, this chip offers the compelling advantages of easy implementation, low standby power, and a very low parts count.

THE SP-1000

There's little doubt that GI intends to shake up the voice world with this chip: it does voice synthesis, can serve as a front-end for voice recognition, and is priced fairly competitively (see table 1).

This chip is highly programmable: you can change its sample rate, and you have a choice of several different pitch pulses. Unlike GI's earlier synthesizers, the SP-1000 uses a lattice-type vocal-tract filter, accepting 10 filter coefficients that all can be set with 9-bit precision. As in earlier designs, the output is a pulse-width-modulated TTL signal, and you can use the same inexpensive RC-filter circuit recommended for the SP-256. Also, the frame length is an integral number of pitch periods, as is true for the other GI synthesizers.

The microprocessor interface apparently is optimized for the 68XX microprocessor series. The only special care you must take interfacing it to other processors is to set up the R/W (read/write) input to the chip *before* the strobe that activates the read or write operation.

Fortunately, this chip requires a 7.16-MHz crystal instead of the 3.12-MHz ones used with the SP-250 and SP-256. The higher frequency enables the crystal to come in a smaller package than the bulky HC-33/U that the 3.12-MHz crystal requires.

Although I won't discuss the voice recognition aspects of the chip here, I'd like

(continued)

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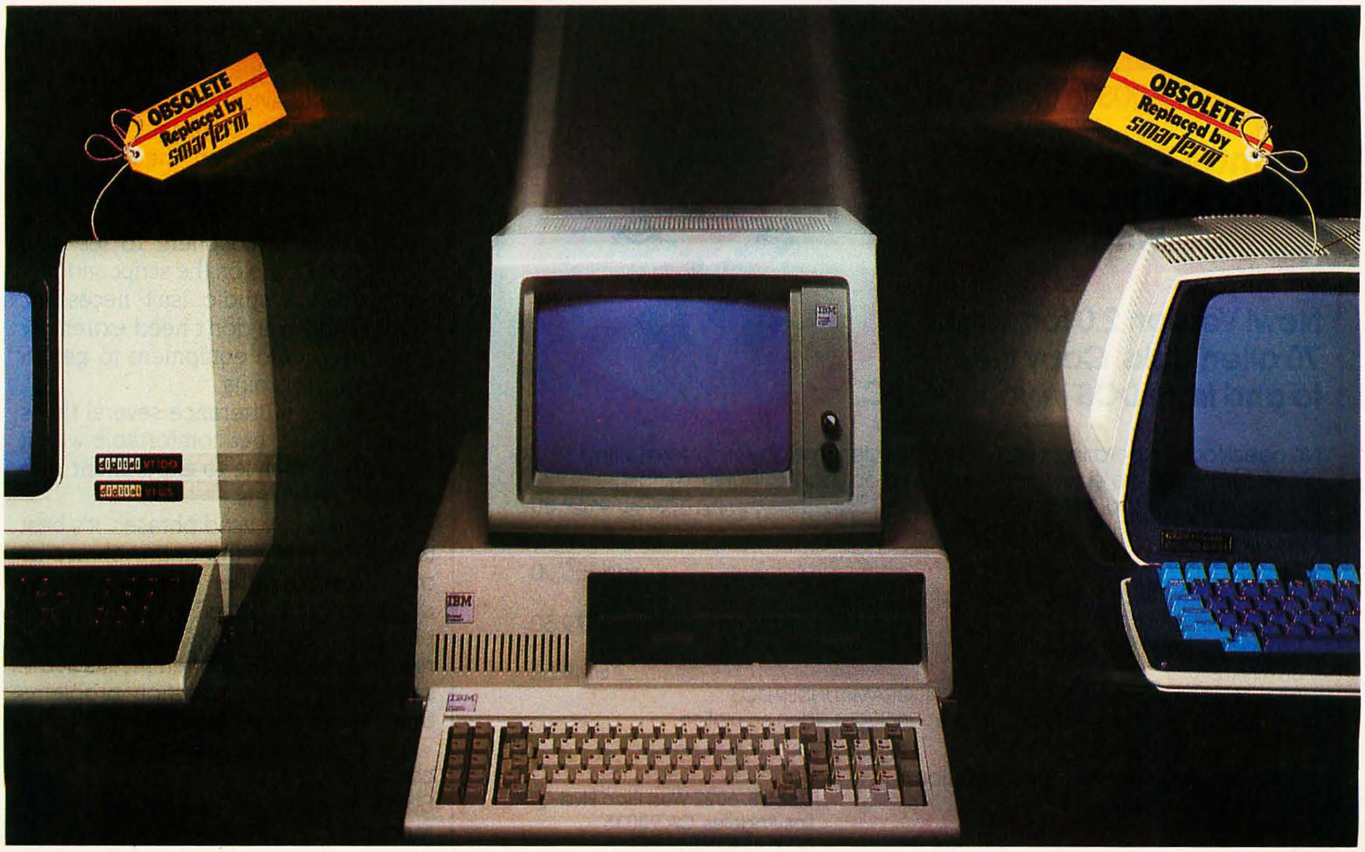

persoft

The only good way to find suitable talkers is to encode their voices.

to say that you can feed voice into it (using an external A/D (analog-to-digital) converter such as National's ADC0831) and get out periodic measurements of energy and eight reflection coefficients. Software in the microcomputer must interpret this data in order to perform the actual voice recognition. You cannot use the reflection coefficients from the recognition mode for synthesis because there are only eight of them, and the technique that is employed to estimate them is not appropriate for voice synthesis.

With a basic data rate of approximately 100 bits per pitch period, the SP-1000 should be capable of reaching the limits of LPC speech quality. You'll probably want to reduce this basic data rate, though, by not supplying full precision to all the coefficients; you need not specify K10 with a full 8 bits, for example. Your driver software will need to unpack the data from the storage format you use. You also might want to implement some kind of interpolation on the coefficients. You also can expect some help in these data-packing issues from suppliers of vocabulary-development equipment.

GI's SP-1000 is a capable synthesis chip that will apparently be priced competitively with other synthesizers that lack voice recognition; even if you don't need voice-recognition capability, you needn't feel that you're paying for something you won't use.

THE STEPS TO LPC SPEECH

Choosing effective words for an application requires effort and practice. It's important to pick the simplest possible way to express a thought while trying to preserve an overall structure to the vocabulary. You can minimize dependence on one person's voice for updates by partitioning large vocabularies, which lets you make changes by altering only one section instead of the whole vocabulary. Also, consider the limits of the synthesizer: expect problems with the same words you have trouble distinguishing in a long-distance phone call.

I don't know any way to predict whether a talker's voice will work well with LPC. Obviously, you want someone who articulates and doesn't talk loudly at the start of a sentence and trail off at the end. But beyond such commonsense techniques there remain considerable differences in quality between talkers. The only good way to determine if talkers are suitable is to try encoding their voices. To help talkers become aware of sounds that cause difficulty, let them get a taste of the voice-editing process and hear what happens to their voices after LPC encoding.

Ideally, you would record the vocabulary in a rented recording studio (about $30 to $50 an hour) to minimize the time spent avoiding traffic noise, squeaky chairs, buzzing fluorescent lights, and echoes from the walls, floor, and ceiling of the room. A studio also can provide a professional, efficient, business-like atmosphere to let your talker concentrate on the script and pronunciation. A studio isn't necessary, though, and you don't need extremely expensive audio equipment to get an adequate recording.

Record each utterance several times to let the talker get comfortable with it and have a chance to experiment with various inflections.

For frequently used phrases, it's best to plan on using the entire phrase as one utterance rather than stringing individual words together to compose phrases. Concatenating words that were recorded separately often results in the same timing and inflection problems that plague phoneme synthesis.

Systems for digitizing a recording and converting to LPC coefficients vary. Some systems change the voice immediately to LPC coefficients; others temporarily store the digitized voice in a high data-rate form and then reduce this data into LPC coefficients off line.

The coefficients generated in the

preceding step usually need to be touched up manually. This interactive parameter editing is needed for several reasons.

First, the analysis procedure might make errors in pitch or voicing. These parameters are notoriously difficult to estimate with complete accuracy, and even a few errors can make the whole utterance seem "buzzy" or gravelly.

Second, sometimes (such as when a voice frame straddles a transition between voiced and unvoiced speech) the LPC model doesn't apply. The operator must take some fix-up measure that makes the speech sound the best, perhaps by deleting a frame or modifying the voicing or energy parameters.

Last, the operator may want to change the way the utterance was pronounced. For example, if the talker pronounced "green" as "green-uh," eliminating the trailing "uh" might make the speech sound crisper.

The time required to edit voice for LPC synthesizers depends on the talker and the skill of the editor. Budgeting about five minutes per word is not unreasonable. Editing is best performed in several passes because listening to an utterance can cause you to focus on some aspects of voice quality and ignore other aspects that can be obvious to fresh ears.

After developing the vocabulary and trying it in your application, get some "naive" listeners to evaluate your vocabulary selection and present their reactions to the voice quality. Revise your design accordingly, going back to step 1 if necessary.

COMPATIBILITY

You can't translate the code for one synthesizer chip into code for a different chip. This is understandable for devices with entirely different filter structures (lattice versus second-order sections), but it's rather frustrating for devices that use the lattice-filter approach. Differences of frame size, sampling rate, coefficient precision, and appropriate preemphasis (i.e., tone equalization for the input speech) seem slight, but they are big enough to make it impractical to try to translate codes from one synthesizer to another. Even beyond these issues, the special quirks in the different devices (such as the "quiet frame" needed by the 5220) block compatibility. Such incompatibility is inevitable in a new technology because manufacturers are trying to both create and track new market demands. Still, it's frustrating; device compatibility could free software developers from having to bet on the success of one particular device and would reduce the risks involved in software development. In fact, an LPC standard already exists. The tax dollars of U.S. citizens paid for its development: the Department of Defense prepared LPC-10 for use in secure, digital-voice communications systems. (See T. Tremain's article, "The Government Standard Linear Predictive Coding Algorithm: LPC-10," in *Speech Technology*, April 1982, page 40.)

There are just two problems with the commercial application of this standard. First, it's designed to run at a fixed 300 bytes per second with no provision for a lower data rate during silent or unvoiced frames. This is almost twice the rate that commercial chips have been seeking. Second, there might be legal problems involved because a special dispensation from a government agency is required to use LPC-10.

It's unlikely that the benefits of this standard will trickle down into the civilian economy, although the development of LPC synthesis ICs is a direct consequence of the groundwork laid by this standard.

WHAT'S AHEAD?

Predicting the directions synthesized voice will take is tricky because so much depends on how hard the market drives the technology. It's fair to say that most players in the industry expected a lot more market pull than has developed to date: we've got a few talking cars, games, and telephone-response systems, but IBM settled for beeps instead of voice in its Personal Computer, and neither the Apple Macintosh nor the IIc includes an LPC synthesizer.

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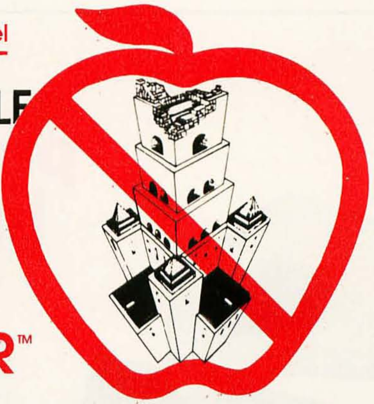

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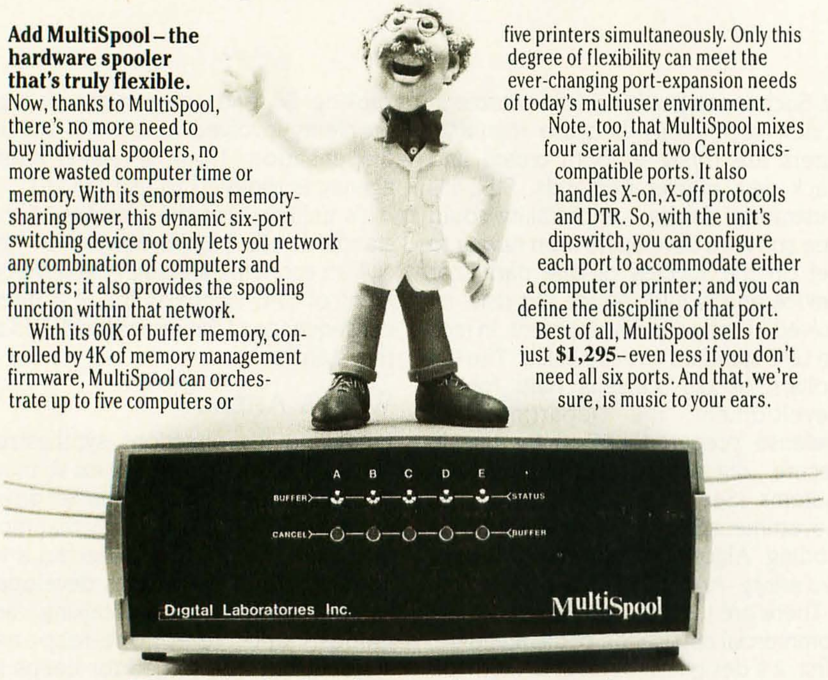

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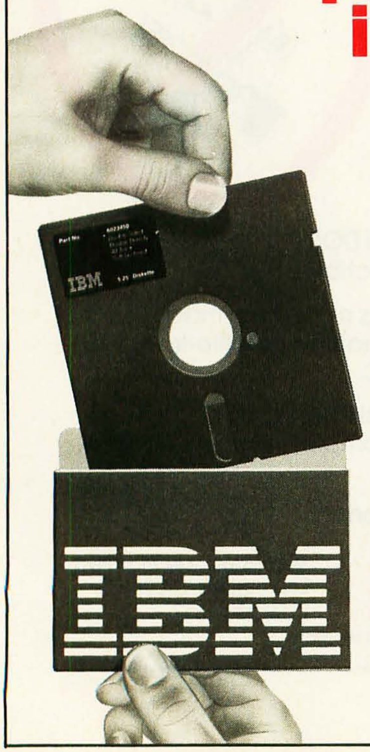

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▲ supplies off-the-shelf ROM

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Customers aren't demanding synthesized voice because they haven't been exposed to a blockbuster application program that uses synthetic voice effectively; the public has seen only gimmicks. This situation will change in 1984 as synthesizer prices decline (this already has begun) and voice-encoding capability becomes more accessible to creative designers.

When semiconductor manufacturers start seeing a return on investments in this technology, they may turn to developing low-cost ICs that strive for high-quality voice (in the range of 400 to 1000 bytes per second) and require very little manual editing. Perhaps these chips will use "multipulse" LPC, an extension of the LPC model that calls for sprinkling a few carefully chosen impulses into the excitation function for voiced speech. Multipulse LPC is fashionable in research circles.

Plain old LPC speech will be around for a long time, though. The synthesizers can be made inexpensively. They provide reasonably smooth speech with natural inflection and timing while keeping voice-memory requirements manageable. ■

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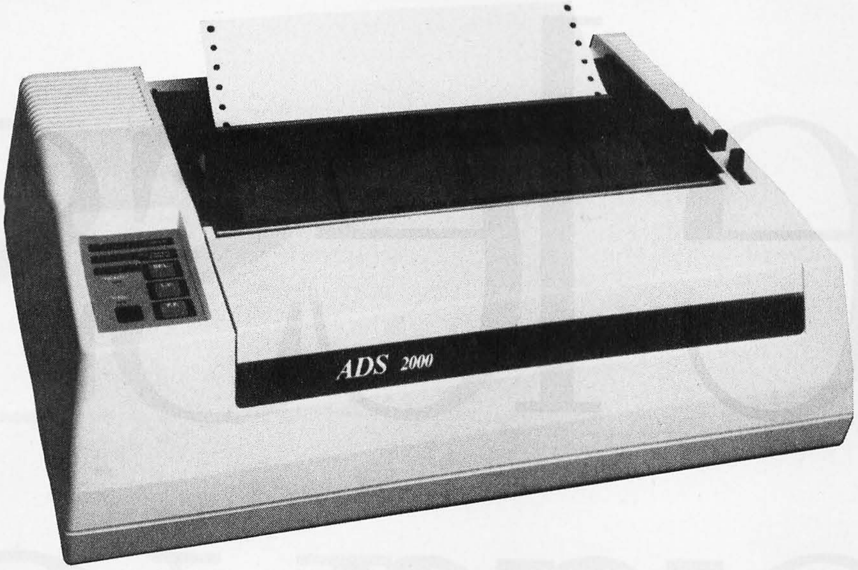

The Antex Data Systems ADS 2000 prints at 165 characters per second in correspondence quality using a 9x9 dot matrix. By turning on the "FINE" mode with a push of a button or through software command it is possible to obtain Very Near Letter Quality (VNLQ) at 40 characters per second using a 17x17 dot matrix. The Epson FX-80 compatible ADS 2000 uses the full 96 character ASCII and includes true descenders and graphic resolution. Typestyles included with the ADS 2000 include Pica, Elite, Proportional and Italics and the ability to design up to 256 characters that can be combined with the standard 128 typestyles. Subscripts and Superscripts can be used for *scientific equations, notations and formulas*. The ADS 2000 can interface to almost any computer on the market using the Centronics parallel interface or the optional RS 232-C serial interface.

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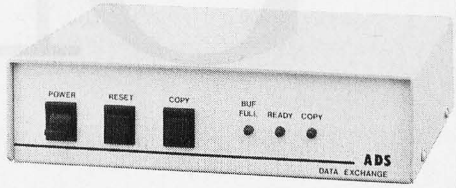

The ADS-8212 DATA *EXCHANGE*/ 64K is a computer independent interface converter and print spooler. It can be installed between virtually any computer and any peripheral.

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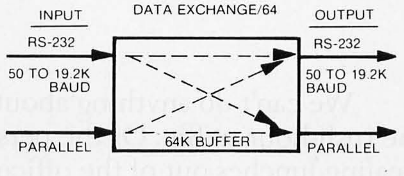
Included with the DATA EXCHANGE/64K are two 4 foot output cables, one parallel cable with standard Centronics type connector and one serial cable with standard DB 25 connector. Standard plugs are supplied for input ports.

Suggested list price: $339.00

Dealer inquiries welcome.



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SOFTWARE REVIEW

Volition's Modula-2 on the Sage

A program-development system rooted in Modula-2

BY EDWARD JOYCE

For the programmer targeting heavy software development toward a p-System, Modula-2 on a Sage computer can be an enticing combination. Modula-2 is a state-of-the-art language from Niklaus Wirth, the developer of the Pascal language. Wirth's latest brainchild embodies low-level access to the machine, independent compilation of modules, and structured programming within a vocabulary of only 40 words.

Hosting the software is the Sage. P-code interpretation drags most computers to their knees, but the 8-MHz MC68000 of the Sage slices through the overhead to deliver reasonable response times.

The Modula-2 package sold by Volition Systems for the Sage resembles similar products the company markets for Apple computers and the IBM Personal Computer (PC). This similarity extends to price, module libraries, and 95 percent of the documentation.

The module libraries furnished with a language such as Modula-2 supply much of the processing power. Modula-2 relegates I/O (input/output), numerical calculations, and storage management, among other functions, to these libraries. Volition provides the minimal library that Wirth defines in his book *Programming in Modula-2* (New York: Springer-Verlag, 1983). The vendor supplements this with extra library routines that, in the words of the user's manual, "provide a portable environment across all of Volition Systems Modula-2 implementations."

The standard library specified by Wirth covers terminal and file I/O and the math functions square root, exponentiation, natural logarithm, sine, cosine, and inverse tangent. Volition's augmented library adds several facilities to this core, most notably decimal arithmetic, string manipulation, and format conversion.

Decimal arithmetic is a boon to programmers writing financial applications. A variable type called Decimal specifies decimal integers up to 19 digits. Canned procedures may be invoked to add, subtract, multiply, and divide Decimal variables. The most convenient aspect of this mode of arithmetic is the method for displaying or printing results. String parameters called *pictures* control the formatted output. Pictures take the tedium out of neatly presenting a numeric or dollar value by inserting decimal points, commas, leading blanks, and floating dollar signs.

Although the string-manipulation procedures of the extended library will be welcomed by many programmers, computer science professors may have mixed emotions. After all, one of the standard exercises in an introductory computer science course is to write routines for inserting, deleting, and comparing strings of characters. In Volition's Modula-2, this exercise is a simple matter of executing a one-line procedure call, hardly the intellectual challenge of writing the routine in FORTRAN, Pascal, or plain Modula-2.

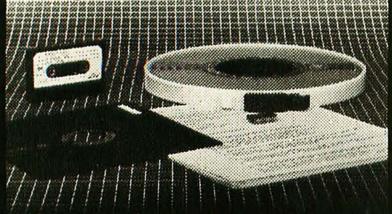
Format conversion rounds out the augmented library. These procedures convert integer, cardinal, or hexadecimal values to strings. You can reverse the direction of conversion from string to integer, too.

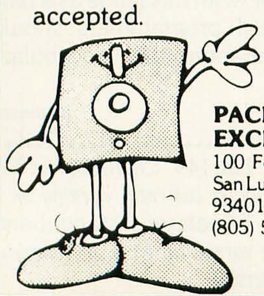
Volition Systems' copious documentation for Modula-2 on the Sage mirrors its Apple and IBM PC counterparts. More than five hundred 8½- by 11-inch pages describe the package. Wirth's *Programming in Modula-2* is also included to clarify the finer points of the language.

The user's manual leaves no doubt as to its intended audience. It states up front that the explanations are geared to Pascal programmers. To this end, the author liberally sprinkles the text with source code illustrating side-by-side implementations of algorithms in Pascal and Modula-2. Additionally, an 80-page section entitled "Differences from Pascal" lays out the precise areas where Modula-2 deviates from its predecessor. With this guide as a handy reference, Pascal programmers should have no difficulty adapting their vocabulary to Modula-2.

(continued)

Edward Joyce (Route 9, Box 149, Charlottesville, VA 22901) *is a freelance writer currently working on a book entitled* Modula-2 Seafarer's Manual and Shipyard Guide. *He earned an* M.S. *in computer science at* Trinity University.





AT A GLANCE

Name
Volition Modula-2 System

Type
UCSD p-System-type development environment

Manufacturer
Volition Systems
POB 1236
Del Mar, CA 92014
(619) 481-2286

Format
Three 5¼-inch floppy disks

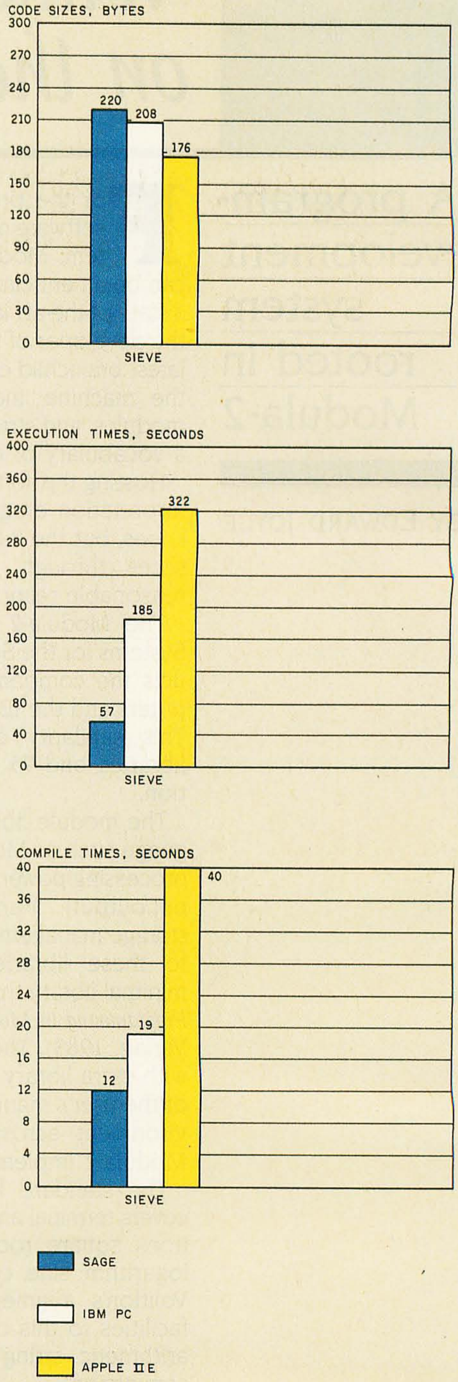
Computer
Sage II or IV

Features
Modula-2 compiler, library, run-time support utilities, editor

Documentation
Modula-2 manual, system editor manual, *Programming in Modula-2* by Niklaus Wirth

Price
$395

Audience
Owners of Sage computers; UCSD p-System programmers



A comparison of code sizes, execution times, and compile times of the Sieve of Eratosthenes program, written in Volition's Modula-2. The program was run on the Sage, the IBM PC, and the Apple IIe.

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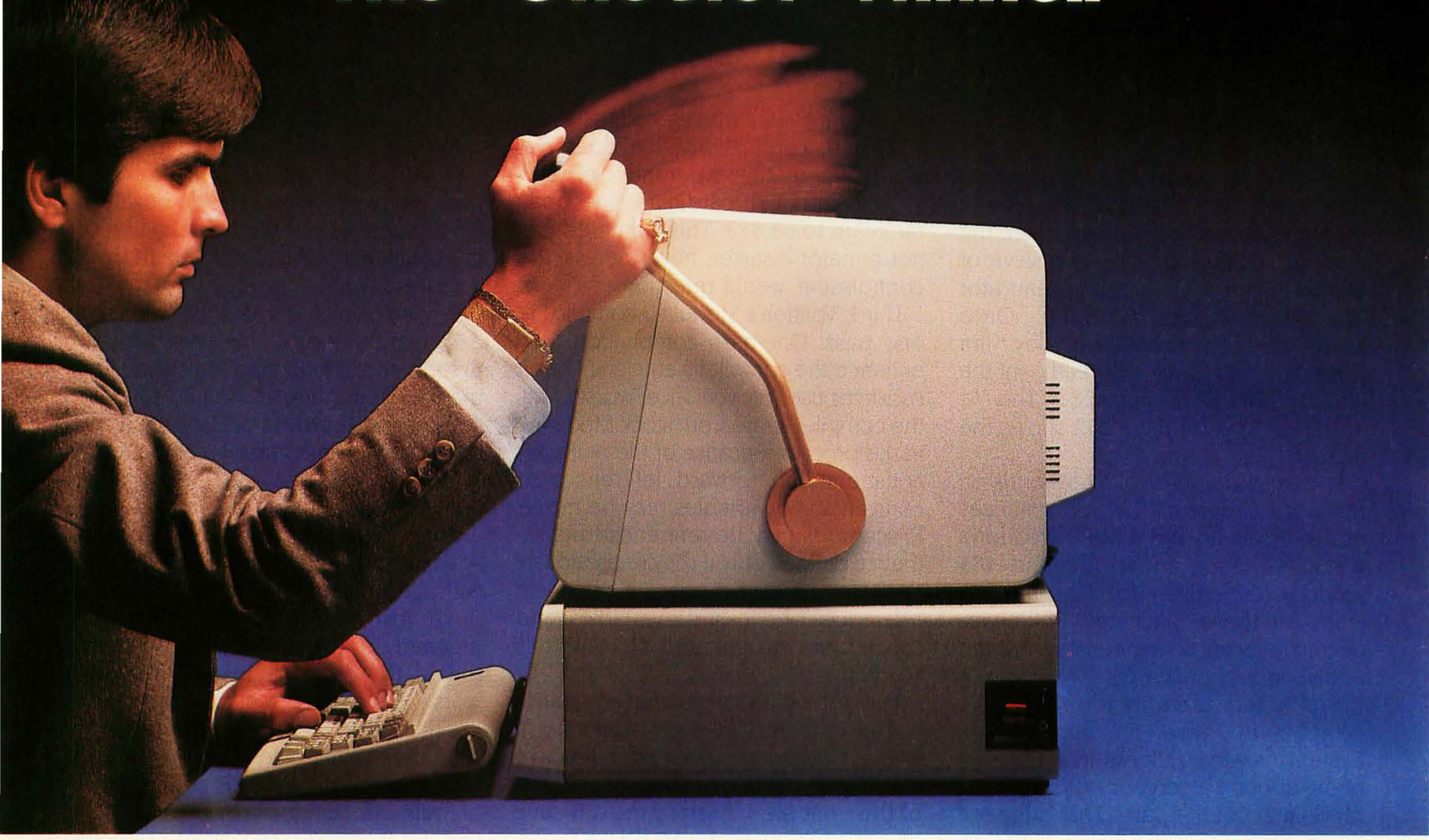

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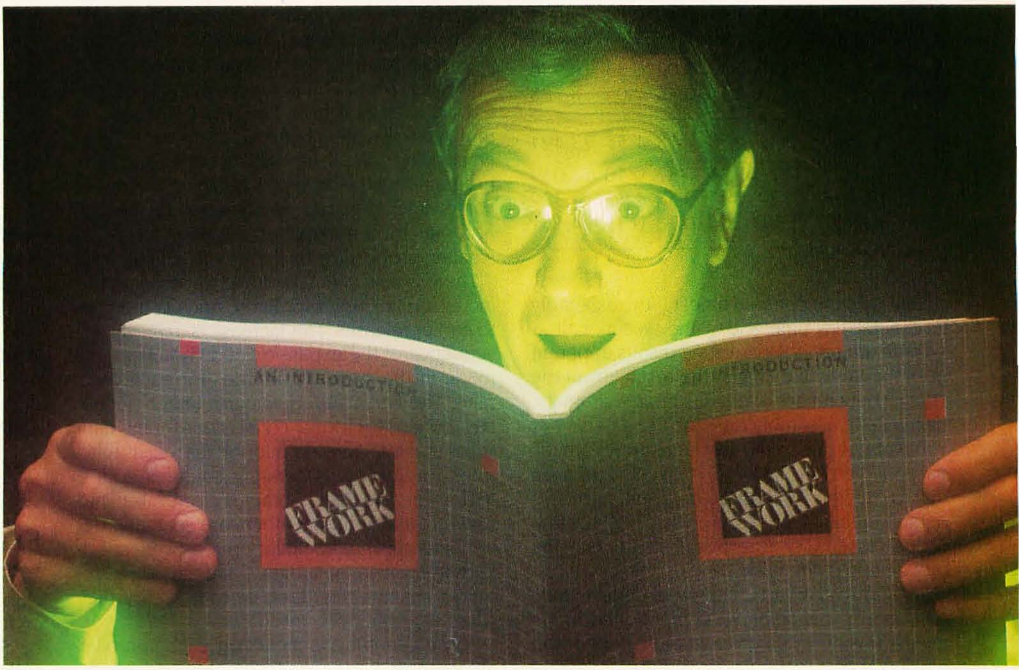

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Kernel

IN THIS MONTH'S KERNEL Jerry Pournelle reports on ThinkTank, an IBM-compatible video board for the S-100 bus, a smattering of clones, NewWord, and a variety of other things. In BYTE Japan, Bill Raike reports on the Tokyo Microcomputer Show. He describes a new high-capacity disk from Hitachi, three microfloppy-based home machines, UNIX workstations, a PROM programmer, and an optical filing system. In BYTE West Coast, John Markoff and Ezra Shapiro discuss a new artificial-intelligence product called M.1 and the latest upgrade of the ZCPR command processor for the Z80.

In BYTE U.K., Dick Pountain reveals the pseudocode of a powerful new algorithm and goes on to offer our first close look at the MC68008-based Sinclair QL.

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BYTE JAPAN: SHOW TIME
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BYTE U.K.: THE SINCLAIR QL
by Dick Pountain 415

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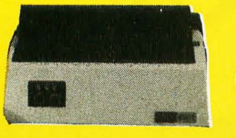

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Basic80, SuperCalc2, Personal-Pearl, and Pilot software for MD5 above	BIMDSMD11SOFT	$ 350.00

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w/dual IBM floppies & 256K RAM	BIIBM51502562	$2150.00
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w/dual ½ height floppies, 256K RAM & 10 Mbyte internal hard disk	BIPDBIBMTEAI10	$3250.00

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Description	Part no.	Price
MBC550-2 MS-DOS 1 dbl/sd drive system w/Grn screen monitor & 80cps printer	BIPDBSY0999	$ 999.00

IBM PC™ COMPATIBLE ADD-ONs

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RIXON 1200baud modem card for IBM with software 3lbs.	BIPDBRIXIBM	$ 459.00
64K RAM expansion for IBM PC™ contains 9-4164's 1 lb.	BIPDBIBMMEM9	$ 54.00

VIDEO CARDS

Description	Part no.	Price
IBM color video card 2lbs.	BIIBM1504910	$ 244.00
IBM Monochaphics 2lbs.	BISTBGRPLS2	$ 395.00

MONITORS

Description	Part no.	Price
IBM 12″ green screen monitor 18lbs.	BIIBM5151001	$ 275.00
TAXAN 12″ green screen for IBM 18lbs.	BITAX121	$ 169.00
TAXAN 12″ amber screen for IBM 18lbs.	BITAX122	$ 179.00
IBM 13″ color RGB monitor 28lbs.	BIIBM5153001	$ 680.00
TAXAN 13″ color RGB monitor 28lbs.	BITAXRGB420	$ 495.00

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Description	Part no.	Price
Dual RS232, 1 cent parallel, clock cal, game paddle port, and 256K RAM card (populated to 64K)	BISTBRIO	$ 319.00
1 cent parallel and 1 RS232 port, clock/cal, and game port card	BISTBIO	$ 199.00
1-RS232, 1-cent par, Clock/cal, game port, and 384K card (populated to 64K)	BISTBRIOPLS	$ 289.00

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EXPANDED QUADBOARD	BIQDRQDBRDXPD	$ 239.00
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QUADCOLOR I™	BIQDRQDCLRI	$ 219.00
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QUADLINK	BIQDRQDLINK	$ 539.00
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Serial expansion for above	BIQDRRS232EXP	$ 40.00
Parallel card	BIQDRIPIC	$ 89.00

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Description	Part no.	Price
INDUS GT for Apple II w/software	BIINDGTAPPLE	$ 269.00
CONCORDE Apple II disk drive add-on	BICRDC111	$ 179.00
CONCORDE Apple II 4 drive controller	BICRDC130	$ 75.00

CP/M™ CARDS

Description	Part no.	Price
MICROSOFT Premium card IIe w/CP/M™ and MBASIC™	BIMSF357760	$ 299.00
MICROPRO Z80B 6MHz card, 64k RAM, CP/M™, and Wordstar 3.3™	BIMPRWDSTRZA	$ 299.00
HAYES Micromodem IIe	BIDCH701400	$ 249.00
DATASPEC 97 function key keyboard	BIDSCAPLKB825	$ 199.00

PRACTICAL PERIPHERALS

Description	Part no.	Price
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Printerface	BIPRPRINTERFACE	$ 59.00
Microbuffer II (serial)	BIPRPMB2PLUS16S	$ 189.00
Microbuffer II (parallel)	BIPRPMB2PLUS16P	$ 189.00

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Description	Part no.	Price
SANYO 18MHz 12″ Green 24 lbs.	BISYODM8112CX	$ 129.00
SANYO 18MHz 12″ Amber 24 lbs.	BISYODM8212CX	$ 129.00
TAXAN 18MHz 12″ Green 18 lbs.	BITAXKG12N	$ 119.00
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TAXAN 12″ RGB color 6MHz 50 lbs.	BITAX210	$ 329.00
SANYO 25″ RGB/NTSC color with dual sound amps (shipped freight collect)	BISYOAVM255	$ 649.00
SANYO TV tuner w/remote control 15 lbs.	BISYOAVT95	$ 349.00

PRINTERS

STAR

Description	Part no.	Price
Gemini 10X 20 lbs.	BISTRGEM10X	$ 269.00
Gemini 10X for IBM PC 20 lbs.™	BISTRGEM10XPC	$ 329.00
Gemini 15X 26 lbs.	BISTRGEM15X	$ 399.00
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Serial interface for GEMINI X series	BISTRSERINTX	$ 59.00
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Description	Part no.	Price
82A w/tractor feed 25 lbs.	BIOKIDAT82AT	$ 349.00
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92A - parallel 25 lbs.	BIOKIDAT92AP	$ 469.00
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MT180L 132 col. 28 lbs.	BITALMT180L	$ 799.00

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Description	Part no.	Price
P1340 serial 30lbs.	BITSHP1340S	$ 895.00
P1340 parallel 30lbs.	BITSHP1340P	$ 895.00
P1351 parallel 35lbs.	BITSHP1351P	$1549.00
Bidirectionl tractr forP1351 6lbs	BITSHA04003	$ 195.00
Single bin cut sheet feeder for P1351 15lbs.	BITSHA05002	$ 995.00

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Description	Part no.	Price
630 60lbs.	BIDBL630	$1695.00
630 RS232C cable	BIDBL32078101A	$ 75.00
630 Centronics parallel cable	BIDBL32083901	$ 69.00
630 IBM PC™ cable	BIDBL32078202	$ 69.00

PRINTER BUFFERS

Description	Part no.	Price
64K Microbuffer (serial) 2lbs.	BIPRPMB1S64	$ 249.00
64K Microbuffer (parallel) 2lbs.	BIPRPMB1P64	$ 249.00
Microbuffer II+ for Apple (serial) 2lbs.	BIPRPMB2PLUS16S	$189.00
Microbuffer II+ for Apple (parallel) 2lbs.	BIPRPMB2PLUS16P	$189.00

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Description	Part no.	Price
40trk, 1sd dbl/dens 5¼″, soft sector 1lb.	BIULT51401	$ 19.95
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MAXELL

Description	Part no.	Price
8″ dbl/dens single sided 1lb.	BIMXLFD1128M1200	$ 27.50
8″ dbl/dens double sided 1lb.	BIMXLFD2XDM1200	$ 34.95

ACCESSORIES

Description	Part no.	Price
Flip'n File 50 5¼″ diskette holder 5lbs.	BIINC03513139	$ 24.95
5¼″ Diskette drive cleaning kit 1lb.	BIPDCFD05	$ 14.95
8″ Diskette drive cleaning kit 1lb.	BIPDCFD08	$ 14.95

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PROMETHEUS Options processor for ProModem 1200	BIPRMOPTPRO	$ 79.00
ProModem 1200 Options processor 64K memory exp.	BIPDBPRMEXP64	$ 59.00
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DISK DRIVES

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Description	Part no.	Price
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2 to 5 Drives $199.00 each / 6 or more Drives $189.00 each		
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MITSUBISHI dbl side, dbl dens 18lbs.	BIMITM289463B	$ 375.00
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TANDON ½ height dbl side, dbl dens 9lbs.	BITNDTM8482E	$ 389.00

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Description	Part no.	Price
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TEAC 96tpi ½ height, dbl side 3lbs.	BITEA55F	$ 179.00
2 to 9 Drives $170.00 each / 10 or more Drives $160.00 each		
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2 to 9 Drives $190.00 each / 10 or more Drives $185.00 each		

5¼″ HARD DISK

Description	Part no.	Price
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TANDON 19.2Mbyte Hrd Disk	BITND503	$ 895.00

DISK DRIVE ENCLOSURES

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Description	Part no.	Price
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ParaDynamics dual rack mount 35lbs.	BIPDN2200R	$ 499.00
JMR Dual desktop 30lbs.	BIJMR2C8	$ 229.00

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Description	Part no.	Price
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JMR Dual full height 9lbs.	BIJMR2C5	$ 89.00
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JMR Dual half height vert. mount 7lbs.	BIJMR2SV5	$65.00
III Single hard disk enclosure 16lbs.	BIIIIHD5001	$ 239.00
III Dual hard disk enclosure 20lbs.	BIIIIHD5002	$ 299.00

S-100 ENCLOSURES

Description	Part no.	Price
ParaDynamics 20 slot floor standing, with provisions for 2 8″ floppies and one 8″ hard disk with power up sequencer (shipped freight collect)	BIPDN3820S	$1195.00
SDS SD300 6 slot low profile desk 20lbs.	BISDS51052	$ 299.00

S-100 HARD DISK SUBSYSTEMS

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S-100 CPU BOARDS

(Shipping weights on all S-100 boards 2 lbs. each)

Description	Part no.	Price
CompuPro CPU-Z	BIGBT51060	$ 269.00
CompuPro 8085/88 dual processor	BIGBT51080	$ 399.00
SDS SBC-300 4MHz	BISDS38095	$ 499.00
SDS SBC-300 6MHz	BISDS38092	$ 599.00
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CROMEMCO SCC	BICRMSCC	$ 495.00
CROMEMCO ZPU	BICRMZPU	$ 395.00

S-100 RAM BOARDS

Description	Part no.	Price
CompuPro RAM 21 / 128K	BIGBT52021	$ 599.00
In quantities of 2 or more: $549.00 each		
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CROMEMCO 256Kz	BICRM256KZ	$1295.00
CROMEMCO 64Kz	BICRM64KZ	$ 695.00
CROMEMCO 2MegaByte RAM CARD	BICRM2048MSU	$8995.00

S-100 RAM DISK BOARDS

Description	Part no.	Price
CompuPro M-Drive/H® 512K	BIGBT52012	$ 975.00
SDS RAM disk 256K	BISDS38082	$ 649.00

S-100 I/O BOARDS

Description	Part no.	Price
CompuPro Interfacer 1	BIGBT133A	$ 169.00
CompuPro Interfacer 4	BIGBT53040	$ 349.00
CompuPro System Support 1	BIGBT56010	$ 350.00
SDS 4 port Async. serial	BISDS38096	$ 449.00
SDS 8 port Async. serial	BISDS38093	$ 529.00
SDS 8 port 4-Async. 4-sync.	BISDS38094	$ 599.00
CROMEMCO TU-ART	BICRMTRT	$ 395.00
CROMEMCO QUADART	BICRMQDRT	$ 695.00
CROMEMCO Intelligent C-BUS™ I/O multiprocessor	BICRMIOP	$ 495.00
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CROMEMCO DAC12	BICRMDAC12	$ 495.00
CROMEMCO ADC12	BICRMADC12	$ 495.00
CROMEMCO D+7A	BICRMD+7A	$ 295.00

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SDS VersaFloppy II with CP/M 3.0™ (a special implementaion by SDS)	BIPDBVF2CPM3	$ 299.00
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CROMEMCO 64FDC	BICRM64FDC	$ 595.00

FOR HARD DISKS

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ADVANCED DIGITAL Seagate 500 compatible	BIADCHDC10015	$ 399.00
CROMEMCO STDC Seagate 500 compatible	BICRMSTDC	$ 795.00
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Seybold Reports

BY JERRY POURNELLE

I think they're trying to kill me. During the month of May I was home for precisely 10 days; the rest of the time I was on the road: at conferences, meetings, the COMDEX in Atlanta, the New York meeting of the American Association for the Advancement of Science, a speech in Cincinnati, and heaven alone knows where else. They say travel is broadening, and I believe it: I put on 10 pounds during that last trip.

Not only that, but our novel, *Footfall*, is overdue, and Judy-Lynne Del Rey, our editor, is threatening to send hit squads, so I've been over at Larry Niven's house 8 hours a day since I came back. The blitz is working: we've done at least a chapter a day since we started that.

All this is by way of apology: my columns tend to ramble, and although I doubt this one is worse than most, there's a second difficulty. I wasn't here most of the time, so I'll have to include a show report as well as some of the doings at Chaos Manor. Fair warning on show reports: I can tell what I saw, but I make no guarantees on anything I haven't actually used.

COMDEX SPRING

It was the first COMDEX in Atlanta and, incidentally, my first spring COMDEX. Just as the hay-fever season ends in California, it begins in Georgia, so I try to stay out of that area in the spring. The really big announcements happen at the fall COMDEX in Las Vegas, or so I've been told. I wouldn't have gone to Atlanta if the AAAS meeting in New York hadn't come just then, but since I was supposed to be on the East Coast anyway, it seemed a good thing to do.

PC COMPATIBLE AT LAST

I'm glad I went, because it was my first chance to see the radical new S-100 board designed for CompuPro by my longtime friend and associate Tony Pietsch. Years ago, you may recall, I said that someone would get rich with an IBM PC-compatible video board to fit the S-100 bus. If anyone listened, they didn't tell me, so I changed tactics: I began to buttonhole the S-100 designers and suppliers. "Don't you see?" I said to anyone who would listen. "There's just too much good software written for the IBM PC for us S-100 addicts to ignore. The S-100 bus is dead if we can't get it to run PC software, and the only way to do that is to have a PC-compatible video board." I must have said that to 50 people.

The only one who agreed was Dr. William Godbout of CompuPro, and he had so many other projects going that he didn't move very fast because all his in-house design people were tied up. Eventually, though, he decided that it was urgent and talked Tony Pietsch into designing it for him. It took longer than Tony thought it would—these things always do—but at the spring COMDEX it was running.

Fair warning: what was shown was a wire-wrapped board. As I write this in early June, the first printed-circuit boards haven't been finished yet. I'm supposed to get a test copy sometime next month. It's scheduled to be delivered this fall, perhaps by the time you read this. I don't guarantee the schedule.

I can hardly wait, though.

Tony's board does both high-resolution (monochrome) and color output. CompuPro used a standard IBM color monitor for the display, but no one familiar with the PC was fooled for an instant into thinking a PC was hidden somewhere in the CompuPro booth. People would wander over to the exhibit, look for a minute, and then mutter, "OK, how did you do that? It can't be a PC. It's too darned *fast*." They were right, too; the board I saw had a rock-solid display, as steady as if it were painted on the screen, and it could completely rewrite that screen in the blink of an eye.

There was more: the board was running under Concurrent PC-DOS (Concurrent CP/M [CCP/M] plus the IBM PC emulation module). This addition to CCP/M has been rumored for months; apparently it's out now, or at least Dr. Godbout's people had one. I don't yet have mine and won't until I get my video board (CompuPro will be able to supply Concurrent

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Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

PC-DOS [CPC-DOS] with the board), at which time I'm going to have to do some hard thinking about what I use for a "terminal" for this system.

I have little doubt that I'll change over to CPC-DOS just as soon as Len Ott, CompuPro's in-house software guru, and Tony finish the new BIOS (basic input/output system) and get it all implemented. My real question is what I'll drive it all with. I hope Tony's BIOS will be sufficiently versatile to let me cobble up a system making use of my Archive keyboard and a large video monitor, so that things won't be much different from what I have now.

There were more goodies at the CompuPro booth. A *production model* iAPX286 board was running at 10 MHz installed in the S-100 "boat anchor." (Those boards aren't cheap; the only reason you'd want one right now is if you were developing software or hardware addons.) The 286 drove the system with Tony's video board (but wasn't the reason his video board is so fast; the PC's I/O is slower than its central brain system). The 286 is upward compatible with the 8088 in the PC, so given the PC video board and CPC-DOS, all the PC software should run on it. The CompuPro people promised me they'll have Flight Simulator running on that system by year's end; I can hardly wait. Of course, if I use the 286, it will have to be artificially slowed down unless I want to practice hypersonic flight.

The final goody was a network of four Shirley machines (Shirley is officially known as the CompuPro System 10). Each Shirley has four users, each user with his own processor and memory. There's a fifth processor for traffic management. We've done little with ours here at Chaos Manor, but that's not Shirley's fault: we're rebuilding, and the place is about to be overrun with contractors and architects. When they're all done, Shirley will become the main machine for the staff, with a link to my own Zeke II system—unless I go all out and replace Zeke. We're still redesigning my final system. In any event, I have enough faith in Shirley to trust my business to her.

I don't have any need for a 16-user system, but if I did, I'd seriously consider linked CompuPro 10s: it's cost-effective, there's a big software base to build on, and the network looked awfully good, with every user having access to every disk drive and printer. Since each user can choose his own names for the other systems in the net—that is, you could call my disk the D: disk while I think of it as the A: drive—there's some possibility for confusion if you move from one workstation to another, but sane organization will take care of that; they don't *have* to have different names to different users unless you want them to.

THINKTANK

Living Videotext had a Macintosh version of ThinkTank at the spring COMDEX. ThinkTank is an excellent product. Indeed, it's one reason I insisted on converting to a PC-compatible system; the program is just too darned useful to do without. Any professional writer not using ThinkTank is probably working too hard.

It bills itself as an idea processor, which is no bad description. ThinkTank organizes outlines. I have a favorite cartoon: it shows a man splayed out in an office chair, foot caught in the wastebasket, arms terminally entangled in the telephone cord, file cabinets spilling papers onto the floor, desktop invisible under paper (in other words, much like a photograph of my office); the caption is, "Life is difficult for the organizationally impaired." It fits me perfectly. I can use all the organizational help I can get.

ThinkTank would be more useful if it were better integrated. The idea-processor part is great; the word processor, i.e., text editor, will never be my favorite for getting lots of work done. It's a bit clumsy, not to say awkward. Even so, the outline generator is well worth using.

You can also get ThinkTank for the Apple II and the IBM PC and close clones (including Zenith Z-150 but, alas, not Z-100). I highly recommend ThinkTank except for one problem. It's the problem I want to write about.

COPY PROTECTION AND PIRACY

The only trouble with ThinkTank is that it's copy protected. It's less obnoxiously protected than most: you can copy the program to a hard disk (which you ought to do), but it won't run unless the original distribution disk is in drive A. That's milder than some copy schemes. Even so, this converts ThinkTank from a durable good into a temporary good, since coffee, kittens, telephones, dust, and stray magnetic fields eventually destroy all disks.

ThinkTank's publisher is Living Videotext; the inventors followed the hallowed micro custom of starting a new company to market their program. I asked the people at Living Videotext about copy protection and was told that they sell a lot of copies of the IBM version to people who've seen it on another computer and decided they had to have it for themselves—but that didn't happen with the Apple version, which wasn't copy protected. They concluded that the Apple owners were giving copies to their friends.

The Macintosh version of ThinkTank is also copy protected. Their stated assumption is that Apple users gave away copies of the program. Their unstated assumption is that IBM PC and Macintosh users will do so unless physically prevented.

Of course, their price might have something to do with the user attitudes. They think they have little choice about the price: given the costs of advertising, of keeping an adequate staff to fill orders, and all the overhead of running a software publishing company, they have to charge a lot. They're probably right, too; but that's the fatal flaw in the whole micro tradition of starting your own company every time you write a new program.

There are economies of scale in publishing. It's not 10 times as expensive to publish 10 different programs as it is to publish just one. Since ideas aren't copyrightable—only the implementations can be protected—it won't be long before someone else comes up with an idea-processor program that does more or less what ThinkTank does. Indeed, I could write one myself, although I probably won't. Someone will; someone smart enough not to start up a new company but rather turn it over to a publisher who'll be able to sell it for a lower price.

The price of software will be driven down to about the cost of a hardbound book. That may take a while, but it's inevitable. When it happens, copy protection won't be so obnoxious: after all, reference books aren't eternal either. They can be lunched by kittens, dogs,

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And Yet More Ethical Problems

I'm often asked which IBM PC clone to buy.

It's a tough question, and like most tough questions the answer is, "That depends . . ."

I'm sure there are a *lot* of good PC compatibles out there. I saw so many at COMDEX that I can't keep track of them all. However, this column, for better or worse, is built around stuff we *use* here; and by use, I don't mean just uncrate it and run test programs. I mean *use* for productive work: creating programs, writing books and stories and columns and letters, making indexes, paying bills, doing my taxes, and generally getting the work done around Chaos Manor.

We can't use everything.

How, then, do we select what we do use, and is it fair?

I try to be fair. We select what we use by employing several parts science, a couple parts whim, and one part blind luck. The science comes in when I try to analyze what new machines are like: what chip, who designed the machine, etc. I may not do it all that well, but I do have some experience—besides, I hear from my correspondents and through the various nets I dip into for information (including one where I'm thoroughly anonymous), so by and large I get a good idea of which new machines are pretty good and which are turkeys.

Naturally I try to work with good stuff. I'm not interested in shooting turkeys. I don't have the column space; there's too much good software and equipment deserving praise to waste time on the dogmeat.

As to what I get: when we see a new product that looks good and hear good things about it, I or one of the assistants write a letter expressing interest. Often we don't have to do that: I'll already have got a letter from the company asking if I'm interested in testing a product.

I usually will, but on my conditions, which are pretty severe: we're going to use the stuff. *Use* is not *test*; thus I'll return evaluation equipment (or pass it along to an educational institution if the owner prefers); but I return it at my convenience, not after some arbitrary time limit like 60 days. I may hang onto it for as long as a year. Some stuff stays longer than that, if I think it's still the best machine for the job it's doing.

Have I then been bribed by the use of the equipment?

No. I'm unbribable for two reasons. First, I have already bought and paid for enough computer equipment to keep me going a long time. Second, and more important, everyone—well, nearly everyone—wants to send me computers. I have, at last count, 34 of them, and we've long since run out of convenient places to put them, so that some end up on the floor. I have to step over two to feed the tropical fish. I don't *need* any more computers, and since I do have a strict rule that nothing sent to me is *ever* sold, it's usually more of an inconvenience than a joy to accommodate a new machine. Even so, I do spend a fair amount of time trying new stuff and making the staff swap the machine they're using for something else—in general, trying to keep up, because that's the job I undertook when I started this column.

I also try to be fair, especially to small start-up outfits. BYTE's editorial staff gives me complete editorial freedom, just as McGraw-Hill gives BYTE's editors editorial freedom; so I'm under no obligation to say nice things about big advertisers. I *love* to discover something new before anyone else does. Probably my greatest satisfaction in writing this column comes from letters that say, "I bought such-and-so on your recommendation, and Wow!, thanks for telling me about it."

Alas, I can't look at everything, whether computers or software. The computer business isn't even my major occupation. I make my living writing books (and if Larry and I don't finish *Footfall* pretty soon, Judy-Lynne is going to see to it that I don't make a living at all). Try as I might—and understand, I *like* these little machines, and I *like* playing about with them, and I even like writing about them, so it's not really work at all—I can't get to all of them.

I really am dancing as fast as I can . . .

children, the brotherhood of book borrowers, Coca-Cola, brandy, and coffee. I don't expect Chemical Rubber to furnish me a free copy of the *Handbook of Chemistry and Physics* just because my kid took it to school and spilled acid on it in chemistry class; and since I can't live without it, I just go buy a new one when something like that happens. I deliberately picked this as an example because it's about the most expensive vital book I own.

Until software costs come down, though, I just don't believe there's any justification for copy protection. Besides, it's so easy to defeat. The ThinkTank scheme was a bit more ingenious than most, but it can be overcome with a demon. A demon is a little program that monitors what's going on and does nothing until he's called into action; this particular demon sits up in high memory in the PC and listens for calls to the A: disk drive. When he hears one, he intercepts it, and if it was from ThinkTank, he feeds back the information the program was looking for. The A: disk is never disturbed, and ThinkTank never knows. We haven't developed a demon for the Macintosh version yet, and we probably won't until we can get a 512K-byte Mac; there's so little free memory in the standard 128K-byte Mac that even a small demon is a significant intrusion.

Incidentally, please don't write to ask for my demon; I haven't figured out what to do with him yet because I'm still thinking about the ethical implications.

MORE ETHICS . . .

On that score, I have another problem. There's a well-known method for patching Microsoft BASIC (for the PC or any other machine) to remove the protection scheme. Once the patch is done, you can edit and list any program, even those distributed in the "Run Only" mode.

One company I know of wants to market a product that does the patch: that is, you run the program; it loads in MBASIC, makes the 2-byte change needed, and saves it back again as MBASIC. That's all it does; once you've run the program, you're through with it. The company wants to market this for $100. That seems a bit steep for what it does.

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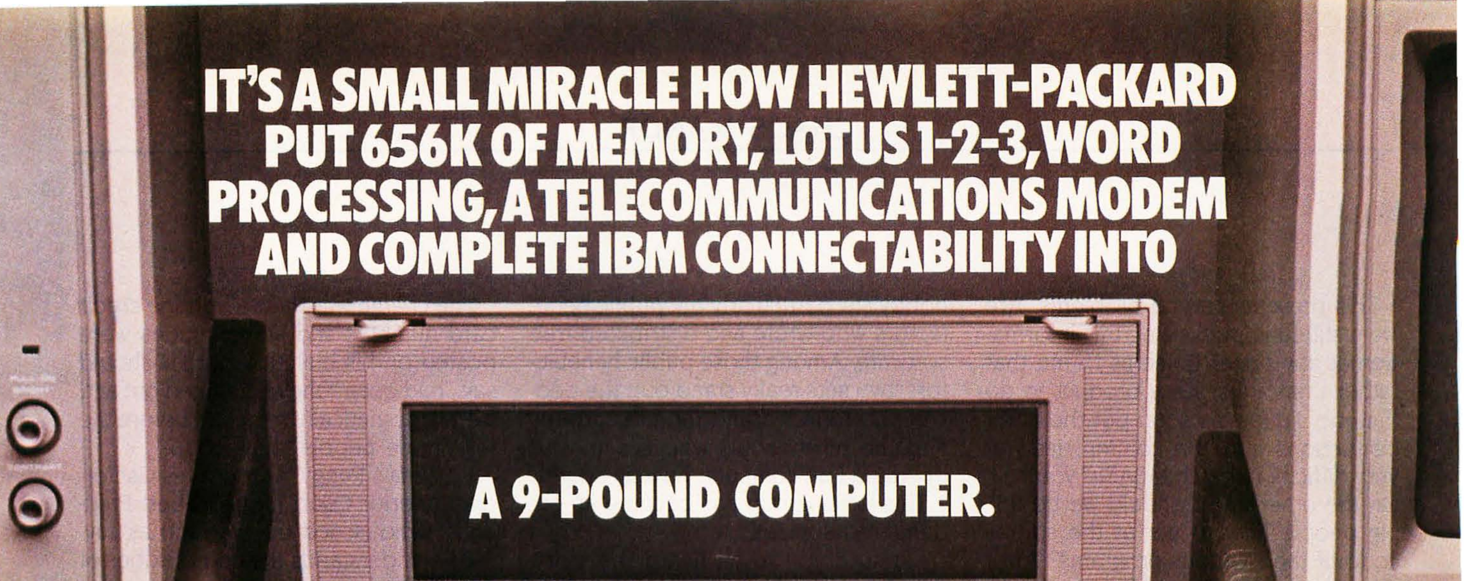

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This presents several problems. Are we justified in publicizing this information at any price? It seems to me that rather than advertise a product to do that job, I'd just as soon put the exact instructions into the column; it's not very difficult to patch MBASIC yourself. On the other hand, should we be telling people how to get at the source code of their various programs? After all, the publishers haven't copy-protected "Run Only" BASIC programs, they've protected only their sources. On the other hand, the patch locations are no great secret; they've been available on a number of computer bulletin boards, so anyone who really wants to learn them can find the information.

There's a lot of other—ah, interesting—information on remote computer bulletin-board systems, including the patch locations to allow you to remove the copyright notice from WordStar or, more ethically, change the timing loop so that the copyright notice doesn't stay on screen so long. Again, anyone really interested can find this information with little trouble.

Putting them on a bulletin board is not, however, the same as publishing them in BYTE.

I'm open to suggestions.

THE RCBS BLUES

The microcomputer revolution would probably have been stillborn without hobbyists, particularly the public benefactors who wrote and distributed free software. Among those public benefactors, two sets really stand out: the people who founded and ran user groups and the hardy souls who set up and operated free computer bulletin boards.

This latter group has become an endangered species.

I'm sure you've all heard the story. Tom Tcimpidis for years operated a free RCBS, distributing software and information. Anyone could call in and post messages on his computer, and anyone calling in later could read those messages. Tcimpidis provided this as a public service, and his board wasn't essentially different from anyone else's. It wasn't filled with pirated software, it wasn't a phone phreak hangout. It was rather wide open, with little or no censorship.

In mid-May Tom was visited by a Los Angeles Police Department detective and two Pacific Telephone Company security officers. They had a felony search warrant. Tcimpidis says their knock at the door was the first he knew of any complaint against him.

They wanted to confiscate all his computer equipment. Since he makes his living with it, that would be tantamount to putting him on welfare. Eventually, the LAPD officer agreed to take only the equipment used for Tom's RCBS, but that was bad enough.

The charge was that telephone credit card numbers and access codes were posted on his bulletin board. I should say "had been"; they had timed out and were automatically removed before the telephone people showed up.

InfoWorld's Peggy Watt quotes California Superior Court Judge Robert Fratianne (who issued the warrant) as saying he understands the complexities of the case because he's seen the movie *WarGames*. I guess that doesn't surprise me; lawyers typically pretend they understand everything, with about as much reason.

This gives me a wonderful idea. There's a local supermarket that I don't much like; I think I'll go down there and post some telephone access codes on its community bulletin board, then make an anonymous call to the local Phone Company. Perhaps they'll get the whole market impounded. To make sure, I'll paint the numbers on the store's wall, so that the whole wall will have to be removed for evidence.

Levity aside, there are some pretty sticky issues here.

Traditionally, both author and publisher are joint tort-feasors in an action at libel; and rightly so. *Libel*, though, is an action for damages after the fact. Although there have been many, many cases in which parties have gone to the law to try to *prevent publica-*

(continued)

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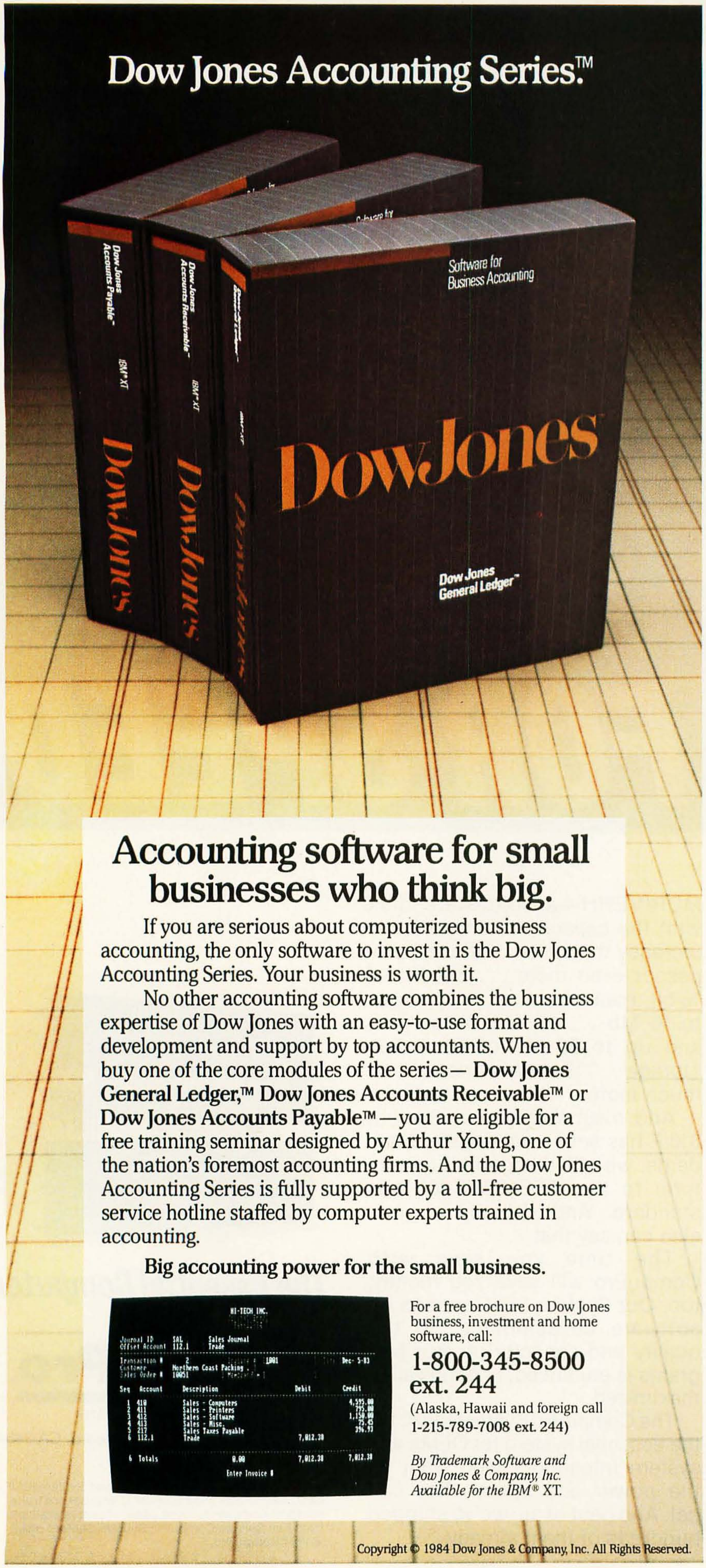

tion of something they believe to be libelous and damaging, and many of them have been able to make very persuasive cases, both state and U.S. courts have always been extremely reluctant to exercise prior restraint.

They almost never prevent publication of stories, no matter how scurrilous, about "public or political figures," and indeed, as William F. Buckley has found to his sorrow, a sufficiently public figure (even if not in politics) has a very difficult time collecting damages after publication. This is probably as it should be: the framers specifically intended a free and independent press as one of the safeguards of the Constitution, and it is worth tolerating much mischief, not to say evil, to ensure a free press. Possibly the courts have gone too far in limiting damages in cases of libel of "public figures," but their reasoning, that the fear of damages will have a chilling effect on publications denouncing those who ought to be denounced, is meritorious if not convincing in every case. Buckley himself admits the principle.

Now, of course, the publication of access codes and credit card numbers is hardly an act of free speech protected by the Constitution. The framers had never heard of telephones, much less computers, but they weren't stupid; given a couple of weeks to understand the facts, they'd have agreed that such publication served no public interest while definitely harming legitimate property rights.

It is a fundamental principle of the English Common Law, and thus the American legal tradition, that "there is no wrong without a remedy." Granting that the Phone Company has been wronged, the remedy is not so obvious.

Collecting damages is likely to be impossible. If those access codes were on Tom Tcimpidis's RCBS, they were probably on others, so that it is manifestly unfair simply to send him a bill for any misuse. Unquestionably, the Phone Company has a real interest in preventing publication of those codes—but that fact is not in dispute. Tom Tcimpidis never asserted a right to publish those codes. He insists that he didn't put them there, tried to discourage users of his RCBS from posting illegal or unethical information on it, and removed the access codes as soon as he knew they

(continued)

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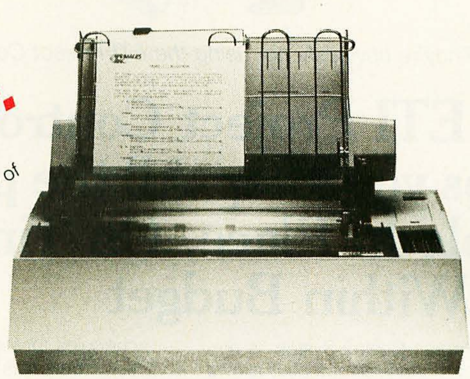

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were posted on his system.

One obvious remedy was for the Phone Company to ask Tcimpidis to delete the codes; perhaps even to get him to sign an agreement to be more diligent in the future.

The Phone Company didn't do that; and while I don't *know* its true motive in bringing the police to confiscate Tcimpidis's computer, I have a pretty fair inference. I suspect it wasn't trying to stop Tcimpidis from publishing those codes; it wanted to put the fear of, if not God, then the Phone Company, into *all* RCBS operators, causing them either to monitor (and censor) what is posted on those boards or shut them down entirely.

The Phone Company was successful. A quick check after the word got around shows that at least 20 bulletin-board systems suddenly went off line. (At last check, though, you can still get "Free Phone Sex" by calling certain numbers. That generates lots of telephone use.)

Query: Is this situation a Good Thing for the Republic?

CLONE OF MY OWN

"Best machine" means many things to many people. For computer whizzes, "best" generally means the latest, with bells and whistles and superspeed; for beginners, "best" may mean a much more limited machine that's been around long enough to have the bugs knocked out. Since most computer company documents are atrocious, "best" to a very naive user may also mean a machine popular enough to have generated books, such as Peter Norton's excellent series on the IBM PC.

Latest and fastest isn't always best—but sometimes it is. Best also changes every couple of months. I'm writing this in June 1984.

With all that out of my system, I can give a preliminary answer to the "which clone" question. I now recommend three systems.

For complete (I don't know of any PC program that won't work; for safety's sake, call it 99 percent) compatibility, a great keyboard, good color, good price, and good service, you'll go a long way before you beat the Zenith Z-150 PC. This machine is so nice that Mrs. Pournelle has claimed ours. The keyboard is *excellent*. It's so PC compati-

(continued)

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Circle 260 on inquiry card.

ble that when we got ours without software, Peter set it up and booted it with the work disk from our IBM PC; no problems at all.

If you build it from the kit model, it's just about the cheapest PC compatible on the market.

If compatibility isn't your main concern, you could do a lot worse than get a TI Professional. This machine isn't anywhere near 100 percent PC compatible and doesn't claim to be, but TI has versions of most of the really swell IBM PC programs. The Professional is newer and faster than the IBM PC.

It has a *great* keyboard, I think marginally better than the Z-150 but not better than the Z-100. We're down at a level where personal preferences and prejudices dominate; all three of these machines have wonderful keyboards, miles ahead of the IBM PC keyboard. (IBM says of its keyboard, "You can't satisfy everybody," to which the only reply is, "Yeah, but you've achieved the astounding feat of satisfying *nobody*.")

The TI Professional is fast, considerably faster than the PC, and has a better display. There are a bunch of features for it; some, like the voice recognition, are more toy-like than serious (but fun); others, like the communications system, are genuine improvements. I'm seriously considering teaching my Professional to be the "master system" that controls most of the other stuff here; if I have to abandon my Archive keyboard and 15-inch screen, the TI Professional (I'll have to find out its name; I'm weary of writing TI Professional) is a leading contender.

Finally, there's the Zenith Z-100, which isn't as compatible as the Z-150 and doesn't have all the features of the TI Professional—but has a lot going for it, including price, lots of software, and the S-100 bus. Zorro, our Z-100, has been a major workhorse for well over a year and is Peter Flynn's main machine for writing letters, doing indexes, and generally getting work done that doesn't require 100 percent PC compatibility. He likes it a lot.

More on all these machines in coming months; meanwhile, if you're in the market for a clone, look into these.

MACUPDATE

Last minute addition: I now have a second disk drive for the Mac. The machine is still too slow and severely memory limited, but with a second drive it becomes capable of supporting real business software. There's a minorly annoying bug in the copy software, but it doesn't hurt anything, and except for that the operating system handles a second disk quite elegantly.

At NCC I saw the beginnings of a flood of Macsoftware, all supposedly ready to ship by August 1. The most important thing was a C compiler from Softworks Limited of Chicago. Given languages and useful software, the

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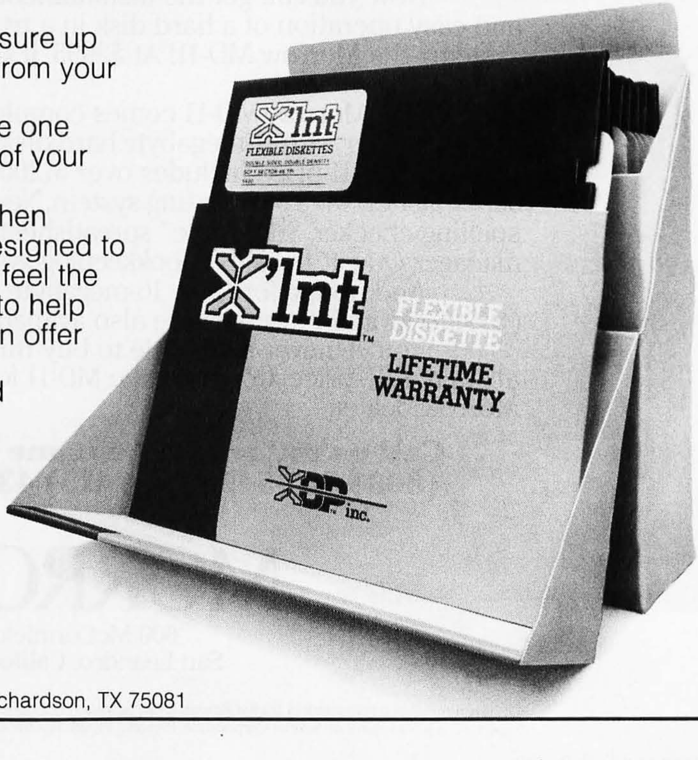

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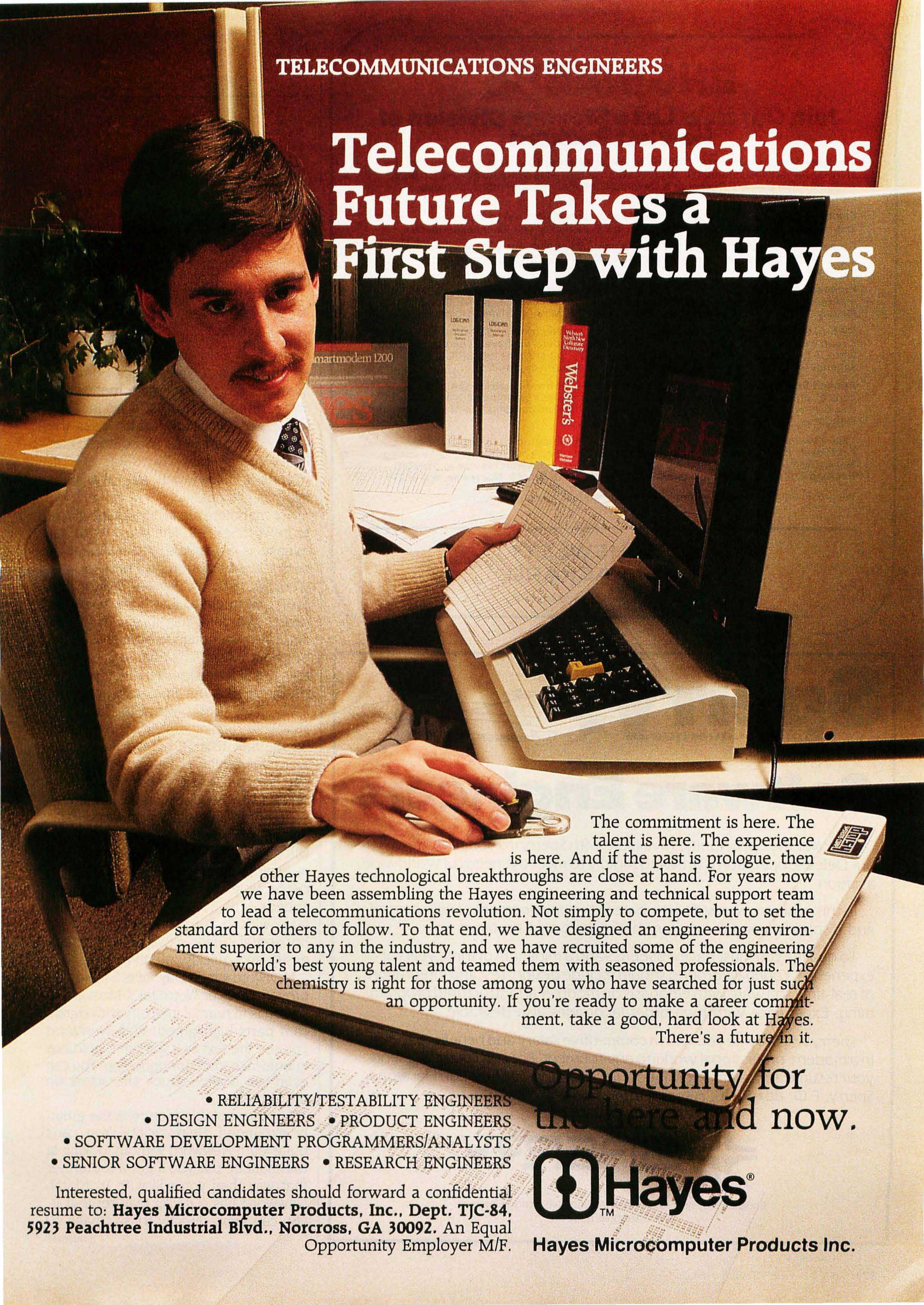

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Macintosh could yet become a computer for, if not the rest of us, at least a fair number. At student discount prices the Mac looks pretty good; I still wouldn't recommend buying one at full price.

NEWWORD

MicroPro, the outfit that developed WordStar, laid off a number of employees two years ago. Some of them went into business for themselves and formed Newstar Software Inc. The result was NewWord, which uses the same commands as WordStar. Peter Flynn, who uses WordStar a lot, describes NewWord as "WordStar without glitches."

Not that there are all that many glitches in WordStar 3.3. The latest WordStar release is a genuine improvement in both documentation and ease of use. WordStar isn't my favorite editor, but everyone ought to learn how to use it; nearly everyone has it, and it's been around long enough to have shaken the bugs out. MicroPro's Charlie Stevenson tells me that versions in which you can kill the *entire* status line are coming up.

We have both WordStar 3.3 and NewWord running on Lucy Van Pelt, our fussbudget IBM PC. Since Peter uses WordStar regularly, I let him take the first cut at comparing them. He mildly prefers NewWord, which has a number of features unavailable on WordStar.

Both programs were run with the Dilog DP-100 RAM (random-access read/write memory) disk; there was no perceptible difference in operating speeds. With a RAM disk both are very fast, with the notable exception of horizontal cursor movement. Files are easily and quickly interchanged.

NewWord's menu layout is a major improvement over WordStar's. Most of the screen is in normal intensity with significant parts highlighted. With NewWord you see the text as it will print, boldface in **boldface**; ditto for <u>underline</u>. You can even see double-struck characters on the screen.

Another notable feature is the greatly expanded Help facility. You can't quite learn NewWord without looking at the manual, but you'll get a lot farther that way than you will with WordStar. NewWord has a paging feature: that is, you can jump directly to, say, page 10

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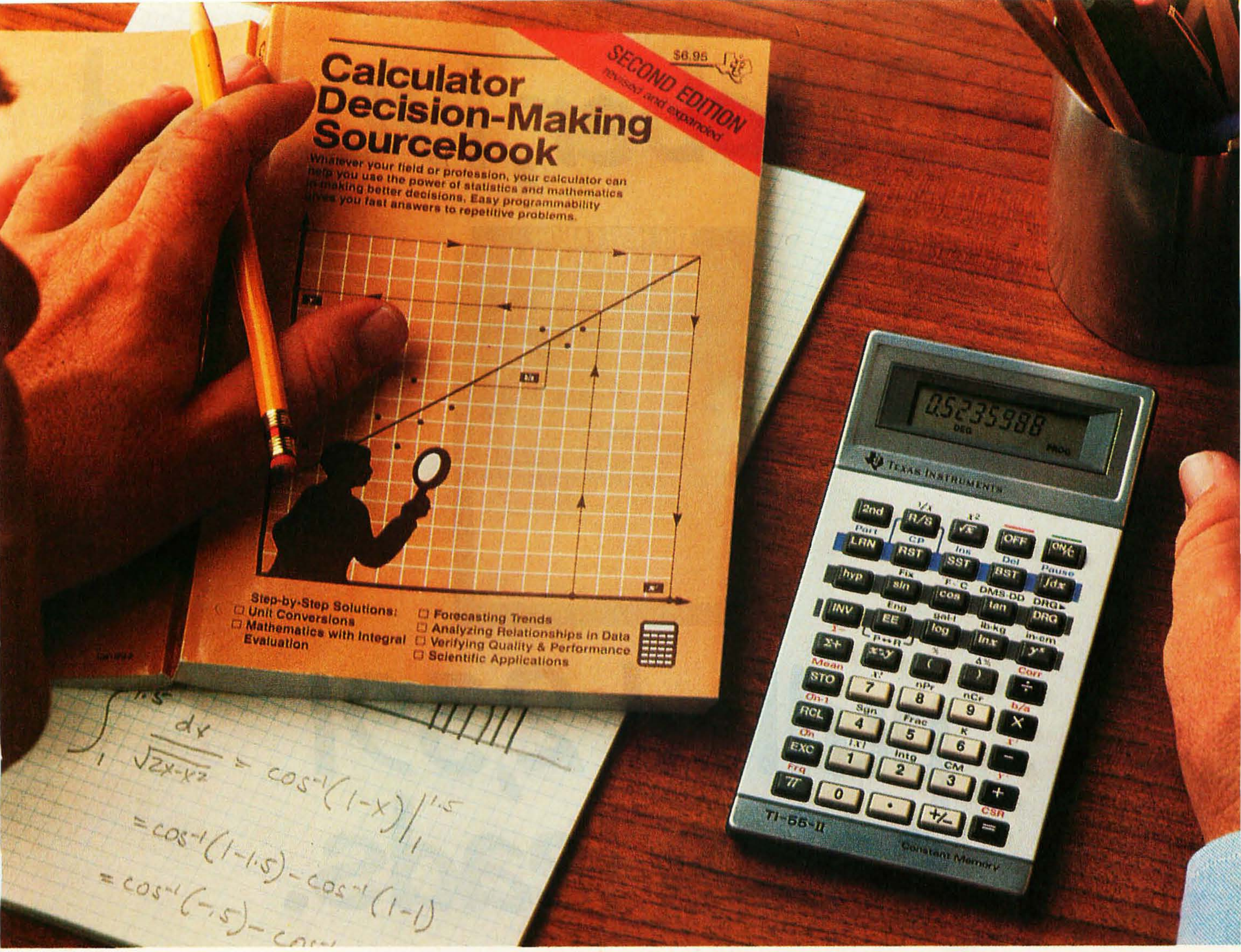

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without scrolling past the previous nine. Not even WRITE has that, and it's a feature I've often wished for.

You can embed "ruler lines" in NewWord, which is to say that you can change formats paragraph by paragraph, and when you reformat the entire document (there's a global command to do that), each will get its proper format. This will be good news for scriptwriters, who have to follow a rigidly structured (but weird) indentation scheme.

WordStar 3.3 had better scrolling than the original version of NewWord; but after I wrote this and sent them a copy, the NewWord chaps fixed theirs so that it's like WordStar 3.3.

NewWord comes with a mailing-list merge program. Unlike WordStar, the program is configured for a particular type of machine; you can reconfigure printers, but there's no installation routine for other kinds of computers, so if you bought NewWord for the Kaypro, you won't be able to run it on the Otrona. Apparently there is a generic version with an Install, but I'm not sure how to get it since configuring it for particular kinds of systems seems to be one of NewWord's piracy controls.

Peter likes the NewWord manual, and so do I. It's a big, thick book with an impressive number of examples, containing both a tutorial and an encyclopedic reference manual. The reference manual is better than the tutorial, but given the improved on-line help NewWord offers, it's good enough.

There is no spelling program for NewWord. That's a pity. The new WordStar spelling program is excellent, the first one I've seen that really competes with Wayne Holder's The Word Plus; but The Word Plus is darned good and costs less than the WordStar spelling program.

The bottom line is that NewWord looks to be at least competitive with WordStar in features, and the undiscounted price is lower; of course, almost no one pays list price for WordStar nowadays.

I always recommend that newcomers to the computer world learn WordStar, not because it will be their favorite editor, but because it's not bad, and it's so universally available. As far as I can see, the command structure of

(continued)

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> *I call Star Fleet I the world's most elaborate star battles game.*

NewWord is about the same as WordStar's.

HOLY WOW, BATMAN!

A couple of months ago I said that I'd written the world's most elaborate Star Trek game. (Incidentally, it's no longer called Star Trek. Barry Workman received a polite but insistent letter. You can still get it as Star Kill.) Anyway, I should have known better than to say a thing like that. There is a star battles game that is not only more elaborate than the one I wrote but more elaborate than I'll *ever* write. In my defense, this one runs on the 16-bit IBM PC, and mine is an 8-bit game, although I recently recompiled it so that it will now run on MS-DOS and PC-DOS systems.

What I'm willing to call the world's most elaborate star battles game is called Star Fleet I. It comes from a company called Cygnus, and it's not just a game, it's darned near a career.

I don't say that lightly. You begin the game as a recruit in the Star Fleet Academy. On graduation you get a test assignment. Your score on that is recorded, and you get promoted (or not; I flunked my first mission). The game keeps track of your service record, awarding your promotions according to your performance. You can even win decorations, such as Hero of the Alliance with Meteors and Diamonds. The program keeps track of that, too, writing it all on the disk so that when you come back to the game in a few days (and you will), it knows what rank you held when you left off.

The game itself has some of the flavor of the original Star Trek game, with galaxy and sector maps, phasers and torpedoes, etc., but there are elaborate differences. For instance, both maps stay on the screen and are updated as needed. This is made possible by writing messages directly to the screen. There are sound effects, and you see the torpedoes move toward their targets.

There are many new commands, most very logically thought out. The game is darned complex. Incidentally, the player isn't expected to be a computer: if the ship's computer would logically do a task, then you merely order it done; you don't have to calculate torpedo tracks and such like.

The designers have been clever with sound, too. For instance: when the game initializes, it gives the message "Please stand by and in awe. The universe is being created." Then it plays the theme from *Also Sprach Zarathustra*, the one made famous in *2001: A Space Odyssey*. I'll let you guess what music the machine plays when you send Marines to board an enemy ship.

The game is fun, but there are problems. The version I have is slow. The game is so elaborate that it has a number of overlays, and it must frequently access the disk. It doesn't check to see if you have lots of memory and load more of itself if you do; the result is that you wait quite awhile for navigation, for the Marines to reach the transporter room, and for other activities. They don't cache the overlays, either, so that it returns to the main program after each overlay command, which is maddening if the next thing you want to do also requires the overlay to load. The slow speed is bearable—but only just.

There are a few design flaws, too. There ought to be a warning message when you're about to run out of time. My Star Kill warns you, so that you know it's time to stop trying to capture enemies and get on with blasting them. In my first trip through Star Fleet I, I got so engrossed with capturing the other guys that I forgot the time factor.

I also managed to crash the game and get an error message, although I wasn't doing anything unreasonable. For some reason, you can't do a lot of backspaces when the machine is waiting for a command. That seems a bit silly. However, the game recovered; only once did I manage a fatal error. Alas, I don't

remember what I did.

Since Star Fleet I is written in BASICA, you must have BASICA.COM in order to play it. I suppose that most PC owners will have BASICA. A letter from one of the game designers—they're all engineers in the space program at Houston—says they plan to compile the game Real Soon Now.

It's a lot of fun, and Wow! is it spectacular in color.

FOR INTERESTED PROFESSIONALS

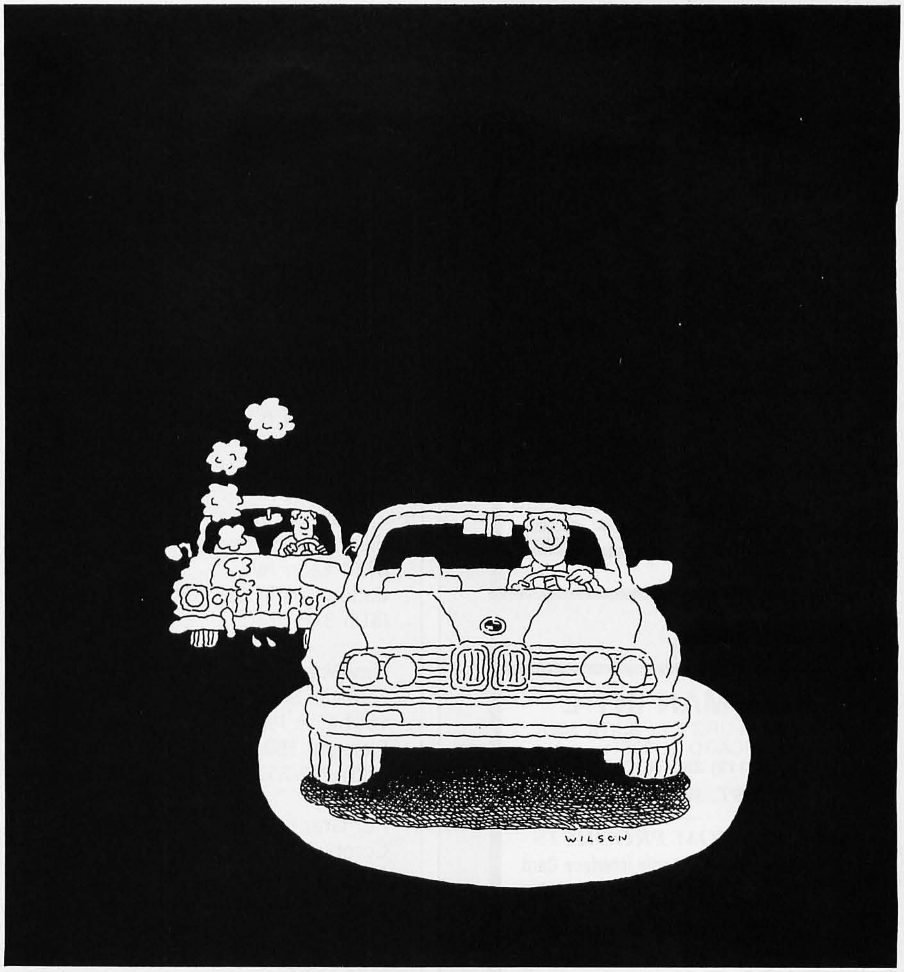
I get about 20 pounds of mail from BYTE every week. One of the things that appeared in my BYTE mail was three issues of the *Seybold Report on Professional Computing*. I don't quite know why; if there was a cover letter, it got lost.

This publication is excellent. Whether it's worth the subscription price, $120 a year, depends on your needs; certainly it could be. There isn't much in it that you won't see if you read BYTE, *Popular Computing*, and *InfoWorld*—but the Seybolds say it a lot sooner. They had an in-depth analysis of the November COMDEX in the December issue and a follow-up in January. Both were excellent. They hadn't selected the same topics that I did—given the size of COMDEX how could you?—but theirs were important enough. They did tend to stay with the "trendy" developments, like Microsoft Windows and Visi On, but they caught some of the less obvious things like the Canon laser printer, too.

The report on professional (as opposed to home or game) computers is one of three newsletters that the Seybolds publish. Their *Report on Publishing Systems* is widely regarded in the publishing field. They also have a *Report on Office Systems*. None of their publications accepts advertising. Interestingly, each issue contains the statement, "Permission will not be granted to suppliers to reproduce any part of The Seybold Report for commercial purposes," meaning, I presume, that you can't use a favorable review from them as a way to plug your products.

At $10 ($12 single-copy price) for a *black-and-white 8½- by 11-inch 32-page* issue, this newsletter is hardly going to steal many subscribers away from BYTE; but those who need to know about

(continued)



ITEMS DISCUSSED

Numerous Items
CompuPro
3506 Breakwater Court
Hayward, CA 94545
(415) 786-0909

Millionaire $59.95
Commodore, Atari, Apple II . $49.95
Blue Chip Software
6744 Eton Ave.
Canoga Park, CA 91303
(818) 346-0730

NewWord $249
Newstar Software Inc.
1601 Oak Park Blvd.
Pleasant Hill, CA 94523
(415) 932-2526

PC Graphics Board $495
CompuPro
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Hayward, CA 94545
(415) 786-0909

Seybold Report on Professional Computing . . $120/year
Seybold Publications Inc.
POB 644
Media, PA 19063
(215) 565-2480

Star Fleet I $49.95
postage and handling $2
Cygnus
POB 57825
Webster, TX 77598
(713) 486-4163

Star Kill $19.50
Workman and Associates
112 Marion Ave.
Pasadena, CA 91106
(818) 796-4401

ThinkTank . . . . Apple II $150
Macintosh $145
IBM PC $195
Living Videotext Inc.
2432 Charleston Rd.
Mountain View, CA 94043
(415) 964-6300

TI Professional . . . . from $2495
Texas Instruments
POB 402430
Department DCA232BY
Dallas, TX 75240
(800) 527-3500

Zenith Z-150 . . . . from $2199
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(800) 842-9000 ext. 1

small computers, in depth and quickly, may find it's a bargain.

I'm out of space and still not done. We've got a mess of ribbon reinkers for revivifying nylon printer ribbons. They range from a spray can you use after prying the top off the ribbon to a machine so elaborate I can't figure out how to put the ribbon in. Reinking is a good idea, provided you wear rubber gloves or don't mind being mistaken for a member of the Black Hand Society; I haven't found any nonmessy way to do it.

The game of the month is Millionaire by Blue Chip Software. If you've any interest at all in investments, you can learn a lot from this one—and it's fun.

The book of the month is Joe Campbell's *The RS-232 Solution* (Sybex, $16.95). It's by far the best book about serial interfaces, cables, protocols, and the arcana of computer interconnections that I have ever seen. If you want your computer to talk to something through an RS-232C port, you desperately need this book.

Finally, we've got Savvy, the darnedest database program I ever did see; a new Modula-2 compiler; lots on the Modula-2 operating system, which, about the time you read this, will be available on Sage computers; no new Macintosh software but plenty more promises; and a whack of a lot of new software we're going to get at just as soon as Larry and I finish this novel, which, I promise you, will be Real Soon Now. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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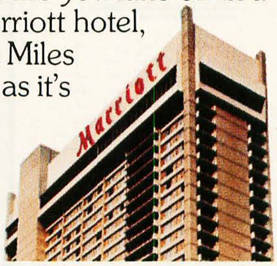

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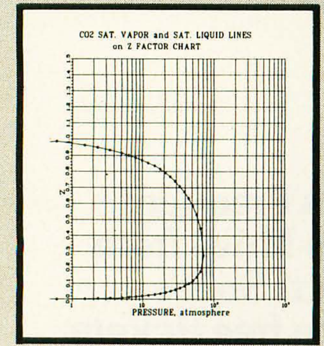
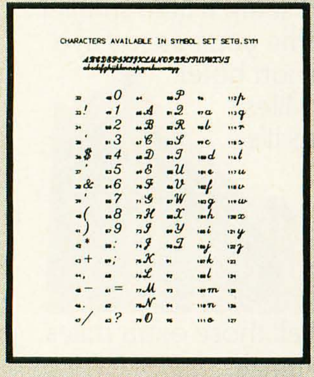
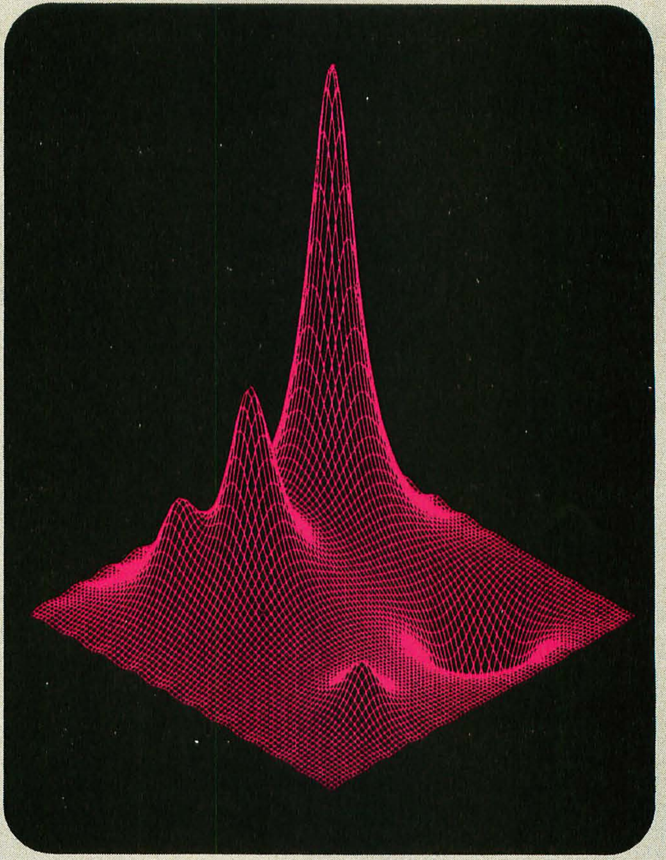
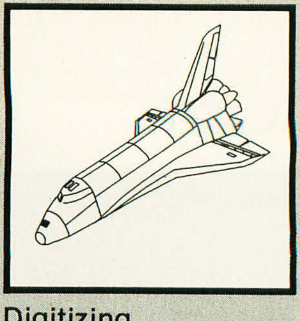


Scientific Plotting

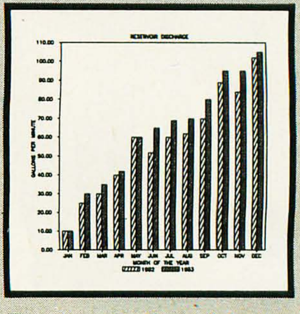


Symbol Sets

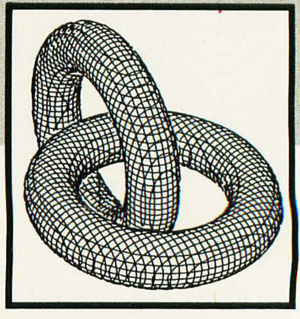




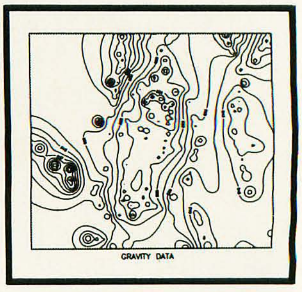
Digitizing



Business Graphics



Program Output



Contouring

PLOTCALL is a graphics system that processes standard plotter instructions into a form that can be printed on over 20 dot matrix printers. This is not another print screen program; presentation quality graphics are created directly on the printer to achieve the maximum resolution possible. (120 x 216 dots per inch for Epson printers)

PLOTCALL includes 17 symbol sets for sign making and plot labeling. Symbol sets may be altered, or create your own! Character strings may be created from any symbol set, rotated to any angle, and scaled to any size.

Plots can be created from any language or from digitized data. An interactive plot debugging program allows you to preview a plot on the screen before sending it to the printer.

All plots in this ad were created with **PLOTCALL** on an Epson printer. No additional hardware is required, not even the color graphics card!

Also included are the following easy to use, interactive programs that utilize the **PLOTCALL** system:

SURF creates high resolution three dimensional surface plots with hidden line removal.

TOPO creates contour maps using the same data as **SURF. TOPO** uses the character routines in the **PLOTCALL** system to provide inline contour labels.

GRAFIT creates charts and graphs of all types – XY graphs, bar charts, pie charts, and line graphs.

IBM PC or compatible with a minimum of 128K of memory and a dot matrix printer with graphics option are required.

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CHAOS MANOR MAIL

DISAPPOINTING CALCSTAR

Dear Jerry,

I have used VisiCalc on my Atari 800 for some time for engineering work, and I naively assumed that the CalcStar bundled with my shiny new Sanyo would be similar. I was greatly disappointed. Some special problems include *no* trig functions, inability to raise a number to a power (x^2 does not play), and no auto-recalculate—this is a manual command.

In addition, the calculations are so slow that you probably could not get anything done at all if you did have auto-recalculate. Square roots, in particular, slow the calculations down horribly.

The only good thing I can offer is that the market apparently realizes this, as CalcStar sells for about half the price of other spreadsheets. I feel even this is overpriced, however, as it is only slightly more useful than Vu-Calc on the ZX81.

The surprising thing is that WordStar is a competent program; perhaps MicroPro has a lot of people who write but don't calculate.

PAT O'NEIL
Gilbert, AZ

I don't know anyone who uses CalcStar; we certainly don't. Thanks for the comments. —Jerry

REJOINDER

Dear Jerry,

Thank you for printing my letter in the February "User to User" column (page 475). I have received favorable comment from some fellow QX-10 users.

I wonder why, however, you jump to conclusions. I do not now and have never owned a Selectric typewriter. That letter (and this one) were done on my QX-10 and Comrex CR-II printer.

HERBERT THOMPSON
Decatur, IL

My apologies. Golly, it sure looked like it was done on a Selectric. That's one nice printer. —Jerry

MULTIUSER SYSTEMS

Dear Jerry,

I am glad to see your prediction that Concurrent CP/M will replace PC-DOS in the PC world. In my work, I evaluate application software for use on a CP/M-compatible multiuser system. I am getting extremely tired of hearing from software companies that their CP/M or CP/M-86 versions are at the bottom of the priority list, with MS-DOS at the top. Wouldn't you think they would at least realize that hundreds of thousands of CP/M systems out there provide a market for their software? Isn't CP/M-based Kaypro the third best-selling name in microcomputers? Isn't IBM now selling Concurrent for the PC XT? Wouldn't you think these companies would realize that the huge IBM PC market also has a huge number of competing companies writing software for it? IBM has turned the majority of the microcomputer industry into a herd of lemmings. (And IBM could well be excavating the cliff at this very moment!)

CompuPro is doing a PC-compatible video board so you'll be able to run PC-DOS software! (That is, unless its copy-protection scheme checks to see if it's running on a PC.) Once again, IBM leads us downward and backward onto the "following edge" of technology. Reminds me of seven years ago when we had to install video boards into the North Star to get Electric Pencil to work.

I can't agree with you that it's better to have one user, one computer. (I'll admit I'm biased, having used a multiuser system for some time now with a virtual terminal board in it, so that I by myself can run several tasks at once in multiple processors.) You're speaking of copying files around from one PC to another on your network, but on a multiuser system you just access them as if they were yours, provided that you are entitled by the password scheme to access that file or program. Furthermore, you are ignoring the situations where multiple users need to access and/or update the same database. Also, multiuser systems make better use of disk storage than multiple computers because you need only one copy of the program stored on disk for several users. And you may be able to network several different brands of incompatible computers together and transfer files around, but you still can't run all your programs on all your networked machines. Let's see you run Edword from the Apple node of your network!

Have you looked at the Wyse-50 terminal? Standard options are 16 programmable function keys (32 shifted), soft setup, emulation of every terminal I've ever used (Hazeltine 1500; TeleVideo 910, 920, and 925; and ADDS Viewpoint), and a 132-*column* mode. SuperCalc in 132 columns is much more useful. Not to mention that it runs at 38,400 bps if you can find a machine to support it. And a nice keyboard with the keys in the right places, including arrow keys where I like them. Two pages of memory, and programmable status line and programmable function-key labels (which I haven't had time to figure out yet). And it retails for $695! The function keys are done right, so it doesn't lose characters on multiuser systems, a rare feature.

KAYE K. CALDWELL
Oakland, CA

I wouldn't count CP/M out just yet. I know that a Concurrent that runs PC-DOS actually exists; why it isn't being marketed I can only speculate.

I too recall the old days when Electric Pencil was the best text editor around, not just for micros, but for any machine anywhere . . .

Thanks for the tips on terminals. I saw a lot of them at COMDEX Atlanta.—Jerry

TURBO PASCAL PATCHES

Dear Jerry,

Here are the locations at which the string-comparison and real-number patches *need to* be written in. First is the floating-point patch location and then the string-comparison patch location.

Floating-point patch: MS-DOS/IBM PC: location cs:0dbe (from 74 to 90) and cs:0dbf (from 15 to 90), MS-DOS/Generic: location cs:0d16 and cs:0d17, CP/M-86/IBM PC: location cs:0de2 and cs:0de3, and CP/M-86/Generic: location cs:0c14 and cs:0c15.

String-comparison patch: MS-DOS/IBM PC: location cs:08e5 (from 73 to 76), MS-DOS/Generic: location cs:083d, CP/M-86/IBM PC: location cs:07fc, and CP/M-86/Generic: location cs:073b.

These have all been tested individually to assure accuracy.

BORLAND INTERNATIONAL
Scotts Valley, CA

Another Pournelle User's Group Service.

You can use the Turbo debugger to install these patches; they fix bugs in earlier versions of Turbo Pascal. These are for the Z80 Turbo only; the 16-bit versions were fixed before shipment.—Jerry

TECHNICAL SUPPORT

Dear Jerry,

We particularly enjoyed your comments on end-user support; it's very appropriate in our case. ("The Technical-Support Dilemma," April, page 64.)

We recently bought a Texas Instruments Professional Computer with a 10-megabyte hard disk, internal 300/1200-bps modem, 256K-byte RAM, 8087 option, three-plane graphics, MS-DOS 2.1, WordPerfect, SuperCalc3, MSBASIC compiler, macro assembler, Emulator 86, COMM TTY, and the noisy fan—our version of hackers' heaven after a year of trouble-free Atari

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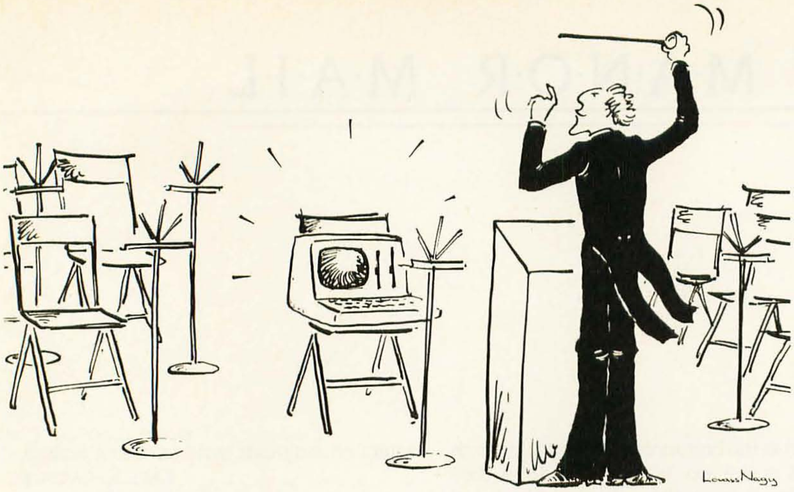

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EPROM Programmers let you program, verify, compare, read, display EPROMS but cost less because they communicate through your personal computer or terminal. No personality modules! On-board intelligence provides menu-based setup for 34 different EPROMS, EEPROMS and MPUs (40-pin devices require socket adaptors). Self-contained unit with internal power supply, RS-232 interface, Textool ZIF socket. Driver software (sold separately) gives you access to all programmer features through your computer, lets you download cross-assembler output files, copy EPROM to disk.

Model 7228 Advanced Programmer —Supports all PROM types listed. Super-fast "adaptive" programming algorithm programs 2764 in 1.1 minutes.

Model 7128 Standard Programmer — Lower-cost version of 7228. Supports all PROM types except "A" versions of 2764 and 27128. Standard programming algorithm programs 2764 in 6.8 minutes.

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XASM48	8048/8041	200.00	250.00
XASM51	8051	200.00	250.00
XASM65	6502/65C02	200.00	250.00
XASM68	6800/01, 6301	200.00	250.00
XASM75	NEC 7500	500.00	500.00
XASM85	8085	250.00	250.00
XASM400	COP400	300.00	300.00
XASMF8	F8/3870	300.00	300.00
XASMZ8	Z8	200.00	250.00
XASMZ80	Z80	250.00	250.00
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EPROM: 2758, 2716, 2732, 2732A, 2764, 2764A, 27128, 27128A, 27256, 2508, 2516, 2532, 2564, 68764, 68766, 5133, 5143. **CMOS:** 27C16, 27C32, 27C64, MC6716. **EEPROM:** 5213, X2816A, 48016, I2816A, 5213H. **MPU (w/adaptor):** 8748, 8748H, 8749, 8749H, 8741, 8742, 8751, 8755.

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511	**8751 Socket Adaptor**	**174**
755	**8755 Socket Adaptor**	**135**
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800 computing. We had to have something more than Atari could offer.

We seriously researched for about three months. The TI Pro won out for several reasons: best color graphics with standard equipment, a rich library of software available, and hardware options (8087) that we were told were available now. There are also about 20 pages of third-party hardware options available. The closest competitors were the Fujitsu Micro 16s and the DEC Rainbow. The deciding factor was a substantial discount from a retail outlet.

Well, there are a lot of things TI did not tell us. And whenever I try to find out anything, I get the feeling that no one is there.

A side note. When we were still shopping, we had some questions about the DEC Rainbow. I talked to a system engineer. He answered my immediate questions and sent me a technical manual. Gratis, even after I told him I was only shopping and did not know if I would buy.

I have gotten some support from the TI regional sales office, but supposedly I am to rely on the dealer for support. The salesperson is trying hard to satisfy us, but he just does not have *all* the answers.

Allow me to elaborate on one specific example. I understand that a programming language must be able to support the 8087 chip. But which specific programs do the job? Will the TI versions of the MSBASIC compiler or macro assembler do it? Microsoft doesn't know; it licenses the program to the OEM. Anyone at TI who will even talk to me does not know the answer. I am supposed to get that kind of technical support from my dealer. The poor salesperson knows how to run the demos, be friendly, and look up prices. The poor guy does not have the technical information and does not understand why I need to know it. Therefore, he does not persist with his sources of support information, and I, the end user, have to swallow another bitter pill.

I have had two TI TTY Communications programs, and neither one was usable. Both disks had so many unrecoverable read errors that the programs would not run, copy, or transfer to the hard disk. With regard to the prices being charged for software, the end user is entitled to an absolutely error free product.

In spite of all our negative comments, we are slugging it out in the trenches and enjoying the learning process. Let's see, after two days now we can copy disks, transfer the invisible system command into the unknown (there should be a warning on that command), read the TTY manual, and look at the WordPerfect program. (The pieces I ordered to construct the printer cable have not arrived yet.) Oh yeah, we can run diagnostics. Ahhhh, but the possibilities . . .

V. A. AND DEBBI WALSER
Staten Island, NY

We just got our TI Professional yesterday. It really looks well made, quite "professional." I hope we're not going to have the problems you did! Fortunately, I sit on a University of Texas Board of Visitors with a TI vice-president, so perhaps I'll be able to get some attention if it's needed.

More when I know more . . .—Jerry

AN AUTHOR RESPONDS

Dear Jerry,

I just read your negative review of my game Legionnaire in the May issue, and I wanted to shoot back at you.

I'll begin by pointing out that the game was designed on and for the Atari 800, and one of my primary goals was to make full use of the special capabilities of that machine. Avalon-Hill decided to translate it onto the Apple against my advice, and I am not surprised that this Apple version generates such a negative review; the Apple simply can't equal the performance of the Atari. Moreover, I did not execute the translation myself, so I cannot vouch for the quality of the programming work.

Thus, I am conceding that many of your complaints about the game are absolutely correct. I will take you to task for several sins.

First, why are you evaluating a secondary product? In fact, why are you wasting your time playing games on a secondary games machine like the Apple? If you want to see the game, why not get an Atari and play the *real* game on a *real* games computer? Games on the Atari are much better than games on the Apple. Try Legionnaire, Eastern Front (1941), or Excalibur on the Atari. It would seem that you have no problem stuffing Chaos Manor with lots of expensive hardware; can you not find the space for a cheap little Atari? I realize that a lot more people have Apples than Ataris, but a lot more people play games on Ataris than on Apples.

I'll also fault you for calling Legionnaire "an arcade game masquerading as a strategy game." In the first place, the verb "masquerade" implies something about the intentions of the designer, and you don't know those intentions, so you misused the verb. In the second place, I designed the game as a strategy game with a real-time element. Fast reflexes are *not* essential to winning the game. Good strategy *is* essential to winning the game. So how can you justify calling it an arcade game?

I agree with all your objections about the poor human engineering of the Apple version. That game is so hard to play that it loses its appeal. It's a great example of how you can ruin a good Atari game by translating it to the Apple.

CHRIS CRAWFORD
San Jose, CA

Well, we have an Atari, but I can only review what I was sent—which was the Apple version. Maybe you can talk Avalon-Hill into sending it for the Atari?

While I have the designer on line—why the devil did you use only part of the screen? One of the most annoying "features" of Legionnaire is having to move the map window around.

As to the rest, "masquerade" referred to the game, not to the designer. It sure felt like an arcade game to me! And you can say that fast reflexes aren't needed, but I thought so; if there'd been a way to slow it down, I would have done so. Perhaps I'll like the Atari version; certainly I thought I would like the game right up to the point when I began playing it.—Jerry

TECHNICAL-SUPPORT IDEAS

Dear Jerry,

I have a few solutions to the technical-support dilemma to suggest.

1. Supply with each software package the names and phone numbers of the last few local people to buy it. You can call them if you need pointers. This could start some new friendships and could also lead to some headaches for users who don't like to get calls.

2. Supply with each package 10 chits for general answers and 4 for technical answers. These could be in the form of randomly selected large numbers. When you call (toll-free number, of course), you would have to give a valid number or they would hang up. If the reason for the call turns out to be their error (software doesn't match advertisement or documentation), you get a replacement chit. This would supply an incentive to keep the documentation up to date. I suppose they might offer chits for sale, too.

3. Give you access to an expert system primed with answers to the most common questions. If it can't answer a question, it forwards it to a human who subsequently adds the answer to the system. This way, a computer handles the boring part of the job. Eventually, you could hope to get an initial expert system (on an optical disk?) with the software.

JAMES R. VAN ZANDT
Nashua, NH

Hah. Your first solution would, I suspect, lead to mayhem. Of course, computer clubs do provide something like that service.

I doubt that software, at least for machines available to most developers, is up to 3.

I like 2. Maybe somebody will adopt the idea.—Jerry

PUBLISHING DELAYS

Dear Jerry,

I enjoy your columns very much. In fact, they're the first thing I read when a new BYTE arrives. However, it's a shame that your column is nearly six months old when it finally gets printed. Can you explain why there's such an outrageous transport lag in the publishing system?

TIM PENNER
Wichita, KS

Consider: I send in an article. A technical editor has a go at it. It then goes to copy editing. Then typeset. Then proofed. Galleys are sent back to me. My corrections are sent back and inserted, and another typeset galley is output. Now the whole magazine has to be pasted up, proofread, and sent to the printer.

Then it's printed and put into the mail. While it's supposed to go out pretty fast, sometimes the letter carriers balk at hauling more than three or four copies at a time and thus spread out distribution.

Wish I had cheerier news, but I don't.—Jerry

(continued)

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MODULA-2

Dear Jerry,

Modula-2 is available on 8-bit machines through Volition Systems. According to information I received some time ago, Volition sells Modula-2 systems for Apple II, Apple III, Z80, 8080, IBM PC, and the Sage II and IV computers, some of which are 8-bit machines. I believe that in the case of the Apple versions you are required to have Apple Pascal.

I program in Pascal on an Apple III computer, and, like you, I look forward to the commercial success of Modula-2 as a successor to Pascal. I have programming experience in a couple of languages and a general familiarity with several others, and I don't see any weaknesses in Modula-2 on a theoretical or practical basis. Further, with new developments in memory availability and faster microprocessors, won't it be great when the speed and memory-space advantages of low-level languages *are* negated and programmers can rely on high-level languages like Modula-2 that are not machine specific?

BRAD REID
Dallas, TX

New developments in computer speed coupled with good high-level languages will bring a new era in software: the return of the gifted "amateur" programmer. That is: most books are not written by salaried teams. They're written by individual authors.

I think we're headed for a time when most software will be written by individual authors not employed in computer companies.—Jerry

TURBO PASCAL

Dear Jerry,

I've received Turbo Pascal from Borland. Although the disk was soaked in some kind of fluid in transit, it could be read without error after a few days of drying. I'm very impressed indeed. Turbo Pascal is *extremely* easy to use. Programs are easy to debug due to the fast compilation and the capacity for Turbo to "jump" to the place the error took place. No more waiting 20 seconds for the compiler to load, only to have "';' expected" flash on the screen.

There are some gripes, none of which even begins to outweigh the ease of use. First, the minimum length of a program compiled into a .COM file is about 8K bytes because Turbo tacks on its library whether you use all its functions or not. Second, the floating-point routines are very slow; a BASIC program in double precision (15 digits of accuracy) outperformed Turbo Pascal, which deals with only 11 digits! (The program calculated pi using the Leibniz series: pi = 4/1 − 4/3 + 4/5 − 4/7 + 4/9. . . It is a good test of floating-point speed.) Third, although execution speed is on par with, say, Pascal MT+, the code is quite untidy, as a disassembly of an empty FOR loop revealed.

Piracy is, as always, still the norm here. There are, as far as I know, exactly two people in my

Circle 299 on inquiry card.

school who have access to computers but don't pirate software. Sometimes the legal (albeit immoral) "copying for personal use" gets out of hand some acquaintances of mine sell the copied software for a substantial profit. Our school computer club recently put out a publication on computers, of which 50 percent of the content was original. Most of the other articles were unacknowledged. They ran an "adapted" article on computer crime in the U.S. Unfortunately, 28 pages later, an article entitled "Pirate's Cove" appeared. It gave information on how to copy a game called Cannonball Blitz as well as how to duplicate Infocom's adventures. I found this extremely surprising, as the publication was endorsed by my school. And that's saying something.

I'm afraid that this is all I have time for. Thanks for taking the time to read this letter.

Victor Chua
1 Sunset Ave.
Raffles Park
Singapore 1128
Republic of Singapore

Once more, thank you for telling me what's going on in your part of the world. If your classmates are as concerned with computers as you are, Silicon Valley may find Singapore as formidable a rival as Japan Inc. Mr. Chua is a high school student in Singapore and would appreciate American pen pals.—Jerry

ALPHA MICRO

Dear Jerry,

In the May BYTE you make two references to Sage as the finest 68000-based system available. I would like to request that you investigate what Motorola has said to be the finest implementation of its MC68000: the Alpha Micro.

This computer is not only a fine machine, but it comes with tools that let developers work effectively: an extended BASIC (better than CBASIC, which is my favorite CP/M BASIC); a quite reasonable assembler with a full-screen debugger; a full-screen editor; three-level sort available from the monitor BASIC or assembler; ISAM from BASIC or assembler; many utilities; a multitasking, multiuser operating system; and a promise of UNIX.

Alpha Microsystems has been building S-100 systems since 1977 and has developed the solid AMOS (Alpha Micro operating system). Version 1.0 on the 68000 did not have many bugs.

Phillip P. Lohnes
Cambridge, MA

Alas. There's only one of me, and even if I cloned myself, I have only so much space in the magazine.

Formal BYTE reviews need to be arranged with Rich Malloy, BYTE's product-review editor. He has a whole bunch of selection criteria to help him decide what they'll review.

I go on whim and accident. As an example, I met Rod Coleman, president of Sage, at a West Coast Computer Faire. A few months later we met again at the Volition Systems booth at the MiniMicro show. I ended up with the Sage in large part because I wanted to work with Modula-2, and that was the best machine for the job.

I don't know anyone at Alpha Micro. I dimly recall the company once had a two-board 16-bit S-100 system called the AM-1, which generated so much interest that the Byte Shop of Pasadena (where I bought Ezekial, my late friend who happened to be a Z80 computer) converted entirely to AM-1 sales. Alas, they are no longer in business, so there went another possible link to Alpha Micro.

I will try to look into this because I do try to find the best; but I hope my readers understand that I can do only so much.—Jerry

EPSON QX-10

Dear Jerry,

As a long-standing admirer of your science fiction, I follow your monologues in BYTE with great interest. When you first chose the Epson QX-10 and Valdocs as whipping boy it was ("alas"?) too late for me. I already had purchased a complete system. In the time since your first lambasting, you have repeatedly chosen Valdocs as an example of what software should not be. I agree wholeheartedly with you that Valdocs is a slow, simplistic approach to "personal productivity," but I fervently wish you would disassociate those comments from the QX-10 itself. It is a fine 8-bit machine, and Epson promises hardware and software updates that should put it on a par with any personal computer in the price range.

Rumors about the new Valdocs (2.0) have been surfacing with increasing regularity. As an insider in the National Epson Users Group, I know only that 2.0 has not yet reached beta test sites. Those who have seen it, however, say it has eliminated *all* the problems with the current version (1.18) and even has overcome the speed barrier by an order of magnitude. Many desirable features will be present. Hardware updates in the form of a hard-disk controller, an internal modem, and an MS-DOS coprocessor already are available, and more are on their way.

Regardless of what becomes available in the future, the fact is that the QX-10 is a dandy word processor as it stands, as long as one stays away from Valdocs. Unfortunately, it is hard for most people to disassociate the system from the software. By contributing to the misconception, I believe you do your readers a disservice.

Bill Brickley
State College, PA

I thought I'd made it clear that one reason I'm so unhappy with Valdocs is that I think the QX-10 deserved a better fate. It's really well made, and with that bit-mapped screen (as well as a character generator), it could support some really nifty software.

The Epson people are working on updates; by the time this gets published, there may be some dramatic announcements. Epson America is in the computer business to stay.

(continued)

Finally, I keep hearing about Valdocs 2.0 but haven't seen it, nor have my spies within Epson.—Jerry

FOREIGN-LANGUAGE CHARACTERS

Dear Jerry,

In the January BYTE's User to User column, two letters (*Move* That Key! and I'll Take Your Epson, page 453) discuss the issue of how to get foreign-language characters with the currently existing hardware and software.

It is a real problem, as any humanist knows! The Modern Language Association of America (MLA) published a note on it in the spring newsletter and was inundated with complaints and suggestions by members—so many that the Association has put together a summary sheet, available to members from MLA headquarters (62 Fifth Ave., New York, NY 10011).

I suggest using the word processor ProofWriter, available from Image Processing Systems, 6409 Appalachian Way, POB 5016, Madison, WI 53705.

Humanities professors in Toronto were recently treated to a demonstration of the program by the author, and it does what it claims to do: with the proper hardware, it will put *any* character you can dream up on your screen and print it out on your printer—not just German ä's and ü's, or the β, but Cyrillic, Arabic, Japanese, Middle Earth—you name it! Perhaps best of all: the company consists of a physics professor and his wife. Not being a megacorporation, they are in the strange habit of actually responding to criticisms and suggestions from users and incorporating the best of these into new versions of their software.

It presently is available for the IBM PC, some of the compatibles (but not the Corona, as yet), and the TI Professional. I have not yet bought it for myself and so cannot say how user-friendly the program is as a whole; but it certainly is worth looking at by anyone who is frustrated with the parochial attitudes of most American hardware and software manufacturers toward non-English characters.

ALAN D. LATTA
Toronto, Ontario, Canada

It sounds like a great program. I'll have to get a copy and have a look.—Jerry

16081 MATH CHIP

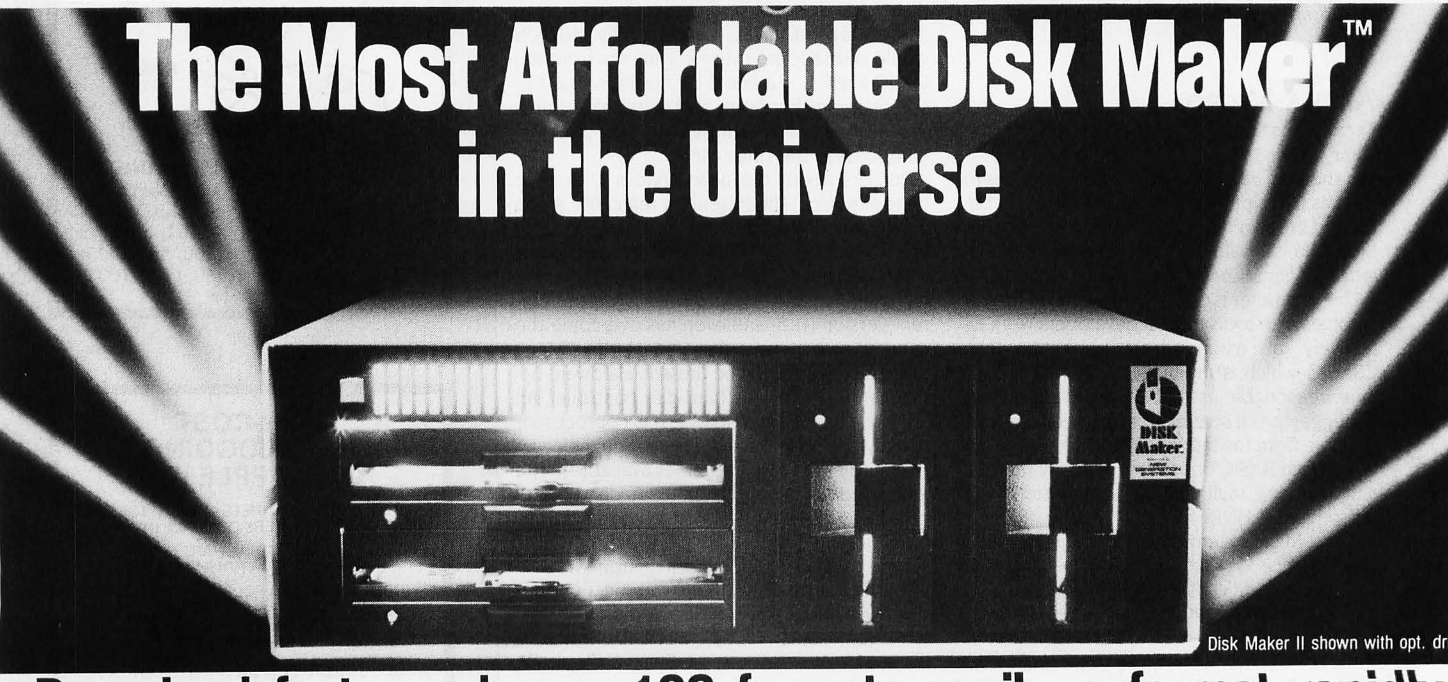
Dear Jerry,

I noted with pleasure your comments in the May BYTE regarding use of the 16081 math chip with the 68000. I was disappointed, however, to see that you didn't give proper credit for the idea. I believe the idea (or, at least, the first publicly announced working embodiment of it) originated with Hal Hardenbergh of Digital Acoustics, who made public the happy liaison several months ago. The detailed plans for a working prototype of a 16081-68000 coprocessor arrangement were published in issue #25 of the DTACK *Grounded* newsletter. Issue #24 had a picture of the prototype on page one. This newsletter, published by Digital Acoustics, 1415 East McFadden, Suite F, Santa Ana, CA 92705, (714) 835-4884, is a valuable source for 68000 and other microcomputer industry news. I had assumed you were already reading it, but since you didn't credit Digital Acoustics for the 16081 idea, I guess my assumption was wrong. You really ought to subscribe ($15/10 issues).

TERRY M. PETERSON
El Cerrito, CA

Hmm. If "dtack grounded" means what I think it does, I need another endless stream of information like I need leprosy. I have heard good things about it, though.

I haven't the foggiest notion of who originated the idea; I'm not even sure where I first heard it.—Jerry ■



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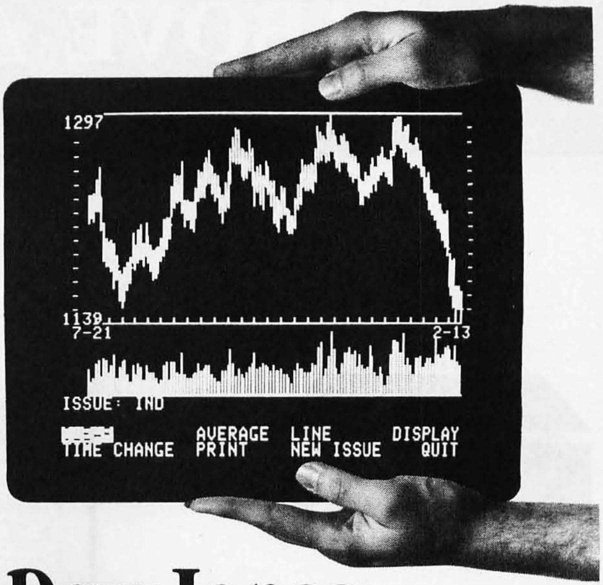

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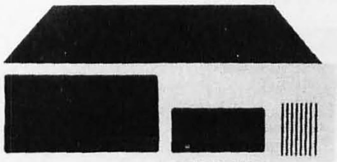

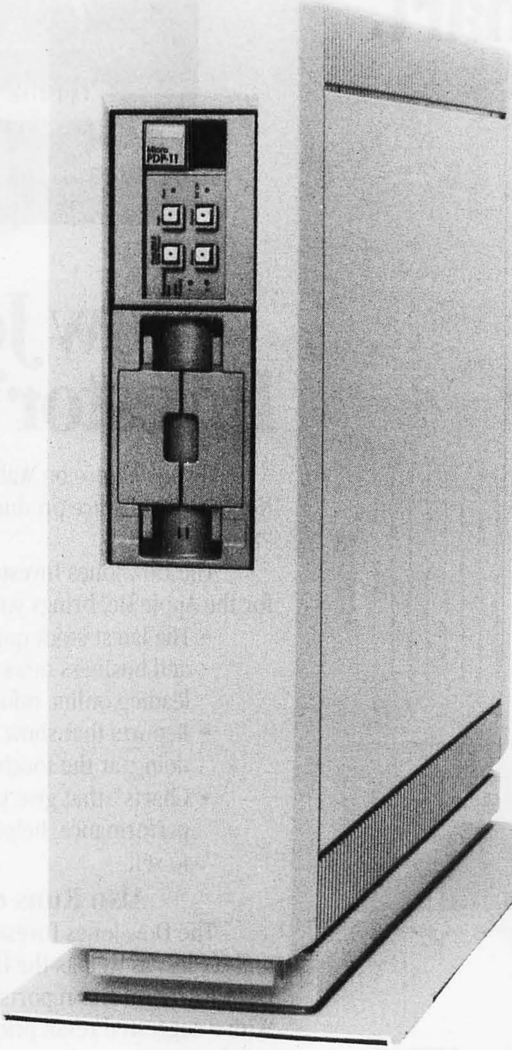

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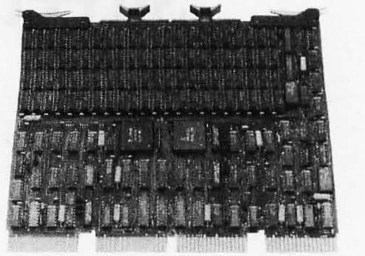

BYTE WEST COAST

News from All Over

A new format, artificial intelligence, ZCPR3, Grid, and other tidbits

BY JOHN MARKOFF AND EZRA SHAPIRO

Defining the scope of a column called "BYTE West Coast" isn't easy; how do you determine where the West Coast ends and the rest of the world begins? There was a time, a couple of years ago, when Silicon Valley was a small community engaged in obscure pursuits well beyond the comprehension of the mass public. It had its own customs, its own language, its own culture. Today, however, computer jargon has become part of everyday speech, and technology stories that were once ignored by the press scream in banner headlines across the front pages of every business section in the country. Most "West Coast" news now has national—even international—impact.

The concept of Silicon Valley has changed with the years, too. It used to mean a very specific locale slightly south of the San Francisco Bay, centered around San Jose. Now the whole Bay Area is immersed in "high tech," and land in the region has become so expensive that miniature Silicon Valleys are springing up all over the country. Every state wants one, and microcomputer companies are besieged with offers of cheap labor and tax abatements from all quarters.

As West Coast editors, our beat now extends from Seattle to San Diego, and as the industry grows, it's rapidly moving inland toward the Mississippi.

Yet for all the expansion, there's still a unique flavor to what goes on in the Valley. There's an intensity of activity, a wild enthusiasm for the frenetic pace that colors daily life here where it all began. Casual conversation is riddled with gossip and innuendo, stories of comings and goings, news that will be stale by sunrise tomorrow. Washington, D.C., may be the seat of government, but Silicon Valley knows—no matter what anyone else might think—that the really important stuff is happening out here.

With this issue, we're beginning to take a different approach to this column, one that we hope will reflect a truer picture of what's taking place on the West Coast. The column will focus on the products and companies and projects and people in our territory that are changing the face of the computer scene—usually as a potpourri of shorter items that suggest clues to the direction the industry will take in the future. What you see here will vary from month to month, ranging from previews to interviews to pure speculation, but our primary aim will remain constant—to analyze the trends that will affect your lives. We're interested to know what you think.

A LITTLE KNOWLEDGE

While there has been a great deal of debate over whether current artificial-intelligence research will yield useful commercial products, there has been even more debate and skepticism over the possibility of making these products useful on desktop microcomputers.

One artificial-intelligence company isn't waiting for the dust to settle. Teknowledge Inc., a Palo Alto-based corporation started by Stanford computer scientist Edward Feigenbaum, has announced M.1, a "knowledge engineering tool" written in the Prolog artificial-intelligence language that's designed to be run in 128K bytes of RAM (random access read/write memory) on the IBM Personal Computer (PC). The announcement may be somewhat deceiving.

While M.1 is intended as a microcomputer-based "exploratory" tool for investigating practical applications in this newly emerging discipline, Teknowledge stops short of claiming that M.1 will allow you to build your own working knowledge systems. Instead, they state that M.1 is aimed at people and organizations that wish to determine the feasibility of applying knowledge-engineering technology to specific problems. Offering M.1 on relatively inexpensive per-

(continued)

BYTE West Coast is prepared monthly by BYTE's editors and staff in San Francisco and Palo Alto. Correspondence should be addressed to BYTE West Coast, BYTE Magazine, 425 Battery St., San Francisco, CA 94111.

M.1 is designed to be applied to the category of what are known as "structured selection" problems.

sonal computers allows users to mock up these problems without resorting to the hardware expense involved in purchasing advanced workstations that are optimized for artificial-intelligence applications.

Teknowledge claims that they are attempting to alter many of the misconceptions about artificial-intelligence research. According to Jerrold Kaplan, Teknowledge's chief development officer, "There is a common misconception that to do significant work you need a specialized machine. You can, in fact, do significant work in artificial intelligence in a microcomputer environment." Still, Kaplan acknowledges that Teknowledge does not consider M.1 a personal computer product in the sense that they aren't seeking customers who merely own PCs and are looking for software. He contends that M.1 will be of interest to corporations that are already Teknowledge clients, but are trying to lower the barrier to creating their own knowledge-engineering tools. (To date, the bulk of Teknowledge's revenue has come from developing knowledge systems for companies with corporation-size computers.)

"Before M.1, it was a couple of hundred thousand dollars," he says. "You had to go out and buy an $80,000 LISP machine, take two guys and set them to work on it for six months, in addition to buying some $60,000 software package." Kaplan argues that M.1 is analogous to the field of knowledge engineering in the same way that BASIC is to programming in general. "It's designed to be easy to use, easy to get up to speed on, and simple, but it's still complete," he claims.

Artificial-intelligence researchers break down problems in their field into a series of categories. M.1 is designed to be applied to the category of what are known as "structured selection" problems. Such problems are characterized by having a limited set of possible solutions; they usually can be solved by using a structured reasoning process. In contrast, categories of problems that aren't appropriate for M.1 include planning and design problems, among others.

The intellectual roots of M.1 lie in several sources. One of these is the EMYCIN framework, a table of if-then rules for representing knowledge that has been widely applied. Another part of the foundation is the LISP language; M.1 allows you to perform basic list-processing operations. It also contains some aspects of Prolog, in particular, M.1's variable-binding mechanism. Generally, Teknowledge has adapted features of various symbolic programming languages and focused them on their uses for representing knowledge as rules in a rule-based system.

According to artificial-intelligence researchers, a knowledge system consists of two parts: a knowledge base containing facts and rules about a particular problem or application, and a program called an inference engine that interprets the knowledge base to create judgments and conclusions. To use M.1, a researcher first must create a knowledge base using a standard text editor on the IBM PC. The knowledge base is constructed using an "English-like knowledge representation language" that can specify a series of up to 200 facts and rules. After the knowledge base has been created, a "consultation" between user and program takes place. M.1 poses a series of predefined questions and offers options based on its interpretation of the knowledge base. The researcher is able to follow the process on an "instrument panel" displayed in a window-based interface on the PC until M.1. reaches a conclusion. During the consultation process the researcher can interactively alter or add rules and facts to fine-tune the knowledge base.

Both the information in the knowledge base and, later, the answers that a user provides during the consultation, can have arbitrary "certainty factors" attached to them. Certainty factors are a way of emphasizing the importance of specific issues to determine an appropriate solution to a problem; this ranking scale enables the program to weight certain parameters more heavily than others. Thus M.1 can make judgment calls—the program can arrive at an answer that has some degree of uncertainty. A less sophisticated program would consider all facts as equally important, and its conclusion would be both absolute and quite possibly invalid. To illustrate the point with a hypothetical medical diagnosis, a patient's prior medical history might be far more significant in determining a course of treatment than his current observed symptoms.

Can useful artificial-intelligence research now take place on the IBM PC? Perhaps. Two of the simple demonstration knowledge bases that Teknowledge developed include a bank-services advisor and a wine-selection advisor, and they suggest a knowledge base that aids the photographer in determining the proper exposure settings when taking a picture—hardly the sort of artificial-intelligence applications that will make the world beat a path to Teknowledge's door.

Another of the demo systems that Teknowledge has implemented on the M.1 illustrates the kinds of limitations faced when artificial intelligence is brought to the PC environment. The SACON (structural analysis consultant) system was originally created by researchers at Stanford University during the 1970s as a front end to give advice on setting up a batch-control job on a mainframe-based structural-analysis FORTRAN program designed to allow engineers to simulate stresses on the structures they design. In this case, while portions of SACON can be run on the IBM PC, the analysis package itself still needs a mainframe computer—it's just too big for a microcomputer.

In the long run, the success of any given knowledge base built with M.1 probably depends more on the researcher's ability to limit the scope of his study to a reasonable size than on M.1's capabilities as a program.

Finally, although it's billed as a personal computer product, M.1 is not being offered at personal computer prices. Purchasing M.1 to construct your own knowledge base will cost a whopping $12,500—steep by most personal computer standards. Of course, the initial pricing of the M.1 knowledge-engineering tool is meant to discourage all but

(continued)

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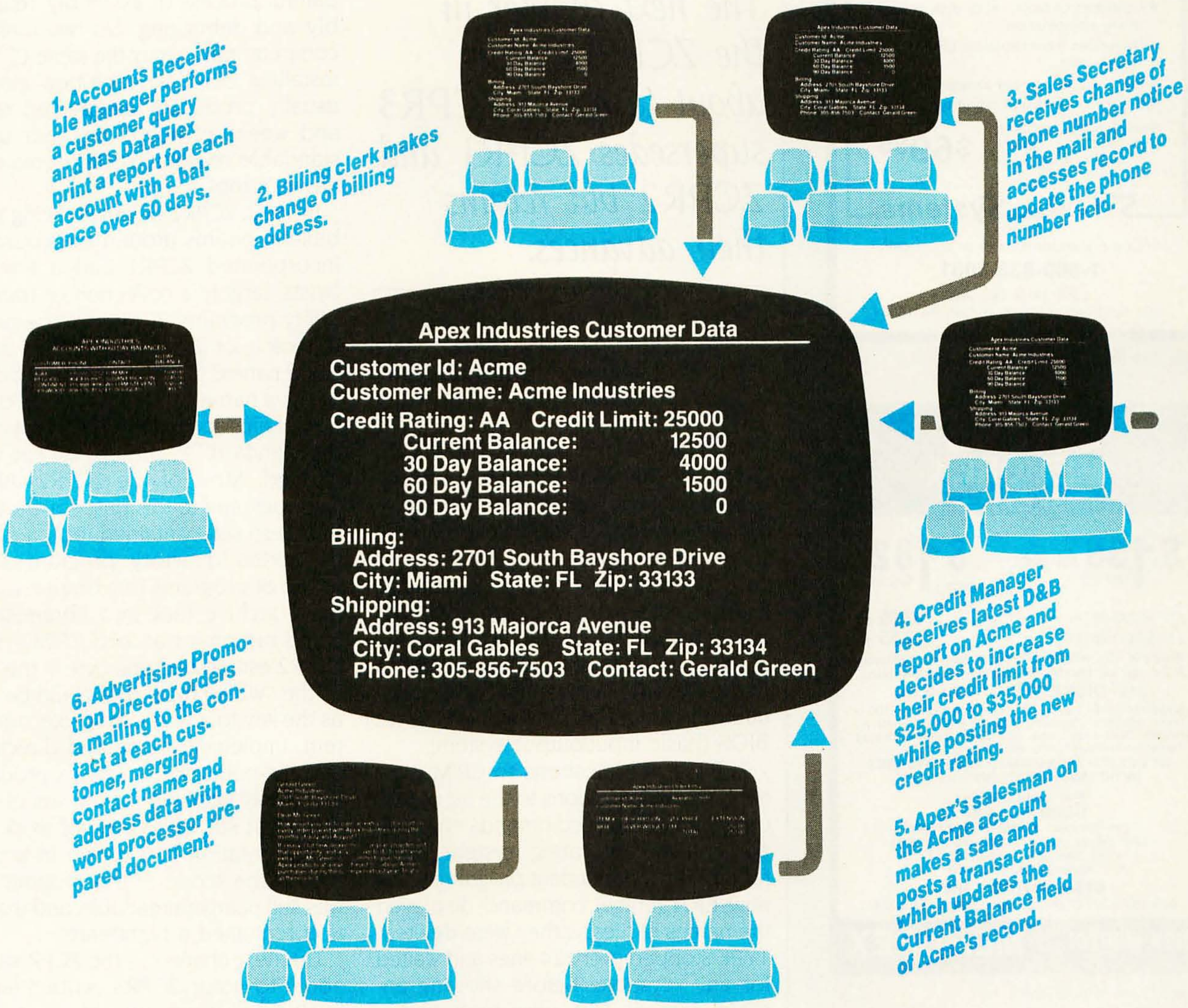

Apex Industries Customer Data

Customer Id: Acme
Customer Name: Acme Industries
Credit Rating: AA   Credit Limit: 25000
Current Balance: 12500
30 Day Balance: 4000
60 Day Balance: 1500
90 Day Balance: 0
Billing:
Address: 2701 South Bayshore Drive
City: Miami   State: FL   Zip: 33133
Shipping:
Address: 913 Majorca Avenue
City: Coral Gables   State: FL   Zip: 33134
Phone: 305-856-7503   Contact: Gerald Green

1. Accounts Receivable Manager performs a customer query and has DataFlex print a report for each account with a balance over 60 days.

2. Billing clerk makes change of billing address.

3. Sales Secretary receives change of phone number notice in the mail and accesses record to update the phone number field.

4. Credit Manager receives latest D&B report on Acme and decides to increase their credit limit from $25,000 to $35,000 while posting the new credit rating.

5. Apex's salesman on the Acme account makes a sale and posts a transaction which updates the Current Balance field of Acme's record.

6. Advertising Promotion Director orders a mailing to the contact at each customer, merging contact name and address data with a word processor prepared document.

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Circle 105 on inquiry card.

The next chapter in the ZCPR saga is about to occur. ZCPR3 supersedes ZCPR1 and ZCPR2 but retains their advances.

the most serious would-be knowledge engineers, and the price does include a four-day seminar with the Teknowledge staff in Palo Alto.

Z WHIZ

ZCPR, the Z80 command processor replacement, has become something of a programming legend. Released to the public domain around 1980 (it's hard to peg an exact date for a program that took a group of volunteers months to develop and debug), the first version of ZCPR was a sophisticated patch to CP/M-80 that corrected what the authors saw as major flaws in CP/M's BIOS (basic input/output system).

ZCPR1's modifications to CP/M were revisions and additions to the list of resident commands (commands that are part of the operating system itself, rather than independent programs). The new ERA (erase) command displayed the names of files as they were deleted; TYPE stopped every 24 lines and waited for any keystroke before showing another screen; DIR (directory) alphabetized the list of filenames; and SAVE, the command to store the contents of memory to a disk file, gained the ability to accept hexadecimal numbers as input, as well as CP/M's standard decimal input. There also were some entirely new commands: LIST sent files directly to the printer; GO executed the program currently in memory; and JUMP moved to a specific address in memory and began program execution at that point.

The program appeared in the software libraries of the larger CP/M users groups and was distributed largely by the growing network of RCPMs (remote CP/M software databanks accessed by modem). However, the documentation was difficult for any but experienced Z80 assembly-language programmers to understand, and installation was a painful process of assembly, reassembly, and debugging. No two makes of computer ran exactly the same CP/M, so installing ZCPR on each new machine usually produced unexpected results and weeks of headaches. For understandable reasons, ZCPR1 remained a hacker's tool.

In 1982, ZCPR2 began showing up on bulletin boards around the country. It incorporated ZCPR1 and a few new twists, largely a collection of transient utility programs. ZCPR2 was beginning to look a lot like UNIX; it could understand named directories. You could give a disk a name and then name a collection of files and never have to cope with the standard "A" prompt except when needed. Most of the ZCPR2 utilities were devoted to this process, though a few were self-contained (e.g., a powerful sorted directory program and a group of programs for compressing related archive files into libraries) and could run on a standard CP/M system. ZCPR2 established one byte in the BIOS as the "wheel byte" that could be used as the key to a password-protection system. Implementing named directories and file paths was a tedious process—extremely valuable for owners of hard disks, but still quite a bit of work. The documentation had grown in proportion to the scope of the program and was still nearly unreadable, and installation remained a nightmare.

The next chapter in the ZCPR saga is about to occur. ZCPR3, written largely by Richard Conn, one of the original authors of ZCPR1, was scheduled to debut in the middle of 1984 with some interesting new features and an entirely new distribution scheme. It is, of course, an evolutionary product, superseding ZCPR1 and ZCPR2 but retaining all their advances.

The major improvement in the software is the capacity to build transient command modules that have to be loaded on start-up but remain resident until the machine is rebooted. The underlying idea is roughly the same as that of COMMAND.COM, the MS-DOS command utility, but users can build their own collection of utilities to be incorporated and configure their systems accordingly. A 64K-byte CP/M system rarely makes use of the entire mass of memory available for a single applications program; CP/M uses a few thou-

sand bytes for itself and even the most extensive applications rarely require more than 56K bytes. The amount of space in memory between CP/M and the application varies from computer to computer; ZCPR3 makes use of the gap.

Once again, ZCPR3 will be kicked into the public domain for single users. The installation, as always, will be beyond most users. However, this time around ZCPR is also going commercial. Conn and Frank Gaude have formed Echelon Inc. in Los Altos, and the new company is trying to sell ZCPR3 to microcomputer manufacturers, corporations, and large groups of users as a CP/M enhancement, as well as selling a number of Conn's other programs. The documentation is still not easy, but it's been cleaned up to a level befitting a commercial venture, and Echelon plans to go all out to support ZCPR3 as a product, with updates, revisions, publicity, and telephone service.

At press time the ZCPR3 was not quite finished and we did not get a chance to work with the software. However, it's worth noting that this is not all radically new technology; the Z80 microprocessor chip, CP/M-80, and much of the ZCPR package have had a chance to mature, and there is little doubt that ZCPR3 will do all that it claims, which is to give the user of an 8-bit computer much of the same flexibility and power advertised for 16- and 32-bit systems.

There will obviously be a lot more to be said on the subject. Watch your local RCPM bulletin board, watch the CP/M users groups, watch BYTE, and watch Echelon.

To be continued.

CLOAK AND DAGGER

Less than a mile as the crow flies from the garage where William Hewlett and David Packard got started is a brand new industrial park populated with a group of high-technology corporations all bent on supplying the next generation personal workstation.

Rubbing shoulders with each other are Grid, Sun Microsystems, and Metaphor. All three of these companies have roots that either directly or indirectly can be traced back to work done on user-interface design at the Xerox Palo Alto Research Center (PARC), which lies several miles away up in the hills over-

(continued)

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looking Silicon Valley.

Although Metaphor hasn't introduced a system yet and Sun is still working on an unannounced low-end version of their 68000-based workstation, Grid recently held a press conference to roll out the newest version of the Grid Compass.

The portable Grid Compass II is evolutionary rather than revolutionary. As such, it comes none too soon, for it's becoming apparent that the market for lap-size computers with desktop capabilities is set to burgeon momentarily.

Until now, Grid has had this slice of the market all to itself—in function if not in price. When the original Compass was introduced, it was widely perceived as being a technological leap forward. Grid was the first portable to use an 80-character by 25-line electroluminescent flat-panel display. It contained both the Intel 8086 microprocessor and the 8087 math coprocessor. And it included 384K bytes of bubble memory for permanent storage. Despite these impressive features, the Compass ran only proprietary Grid software and came with a stunning price tag of more than $8000, which—in the minds of many—confined it to the category of high-priced toys for status-conscious CEOs.

Actually, although Grid has not yet obtained a significant commercial market, the company has found a major potential buyer in the military and intelligence communities. A special Grid Compass that is "Tempest" qualified has proven of interest to the National Security Agency. (Tempest standards for electromagnetic interference levels that fall below a classified cutoff point are designed to ensure that certain types of electronic equipment are undetectable in field operations.)

The addition of the Compass II to the Grid lineup has permitted the company to gracefully lower the price of the basic Compass by a full 30 percent to $4250; $4995 with a built-in 1200/300-bps (bits per second) modem. This will place Grid at a more reasonable high end of the new lap-size market, less than $1000 higher than the new Hewlett-Packard 110, for example.

The Compass II, however, can add up to a half megabyte of ROM (read-only memory) in increments of 128K bytes. The newer model will be priced at $6795 (the 512K-byte version will cost $7995) and will come with one 128K-byte ROM pack that contains system utilities. Additional ROM packs with different applications software will be available for purchase separately. Grid will be supplying the MS-DOS operating system and popular MS-DOS programs such as Multiplan, WordStar, dBASE II, Condor DBMS, and Lotus 1-2-3. The company acknowledges that each MS-DOS program has to be rewritten for the Grid because its display has a 320- by 240-pixel resolution—completely unlike that of the IBM PC.

While Grid has only slightly altered the product design of the Compass, the original concept of support hardware

(continued)

for the "mobile professional" has altered dramatically. When the Compass was first introduced, Grid envisioned that each corporate customer would purchase a "Grid Central" IBM minicomputer to act as a remote host from which the Compass would download software. However, the Grid Central soon died from lack of interest and was replaced by the Grid Server and the concept of the remote-area network (RAN).

The Grid Server is a combination file, print, and communications-management system that uses the Intel 80186 microprocessor. It's designed as a base station to support a local-area network of up to 48 Compasses and IBM PCs, plus another 10 remote systems. It will run both Grid and MS-DOS software. Grid also has introduced a variety of other peripherals for the Compass including floppy and hard disks, printers, and plotters. They're also offering a Compass workstation model for the office network configuration that comes with bubble memory and sells for $3450.

With the Compass II, Grid has lighted a small candle at the altar of IBM compatibility. Whether this is enough to develop a consumer market—given recent price cuts from IBM and rumors of other lap-size portables from Compaq and IBM itself—is yet to be seen.

But Grid seems to be in decent shape regardless of its fortunes in the commercial sector. There is a good chance the black, briefcase-style Compass with its sexy lines and "high-tech" styling will become the portable computer of choice for the Pentagon, intelligence agencies, and Federal Bureau of Investigation. In fact, SAI, a San Diego-based defense contractor, is now working on an OEM (original equipment manufacturer) version of the Tempest-qualified Compass that will be perfect for banging around in hostile environments.

BRIEFS

If Ellis Computing's Nevada Pascal at $39.95 seems strangely familiar, that's because Chuck Ellis purchased the program from James R. Tyson, author of JRT Pascal. Tyson, who owns the copyright to JRT Pascal, version 4.1, as an individual, sold Ellis 5000 copies of a CP/M-80 product to be marketed as Nevada Pascal, and another 5000 for MS-DOS that will be called Utah Pascal. . . .

The war of words is getting worse. Having already reduced such choice phrases as "integrated," "user-friendly," "full-featured," and "environment" to meaninglessness, the software-promotion writers are moving to destroy new targets in the English language. "Intuitive," "idea processing," "natural language," "user interface," and "English-like" are growing in popularity and can be expected to become verbal rubble in a few months' time. . . .

Micom has introduced the DialNet3000 Model 3024, a 2400 bps auto-answer modem priced at $795. At the same time, Tymnet, the dial-up data communications network, was announcing expansion of 2400-bps service to a total of 16 major population centers. Will this be the next standard speed level for microcomputer data transmission? Hard to say, though many experts have been predicting a jump from 1200 bps to 4800 bps, ignoring the 2400 bps level. The 4800-bps modems are still hovering around $2000—well outside the range of most single-user budgets. Any definitive answer to the question will depend on the dance of the corporate elephants who determine price structures. Speeds above 9600 bps probably will have to wait until the telephone companies make the move to digital voice transmission, which they see happening in the early to mid-1990s. . . .

Research from Control Data Corporation, Sorcim, and CompuPro indicates that the size of the average office working group is approximately four people, which adds fuel to the argument that multiuser business computer systems make more sense economically than local-area networks, at least for productive day-to-day file sharing. The companies with LAN-based products really

(continued)

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haven't lost the round, however; they could point out that such multiuser groups should be linked in a star network to communicate with each other.

Watch for outline processing to become a significant new concept in integrated software. The incorporation of an outline processor by Ashton-Tate's Framework package may start a stampede to spread this application. Ashton-Tate has already decided, between announcement and release, to add communications software to Framework to make it more competitive with Lotus's Symphony. If outline processing is perceived by the software manufacturers to be an equally important feature, nobody will dare to be without it. . . .

One major Silicon Valley manufacturer intends to offer a computer with a mouse sometime early next year. However, the company has run into a slight snag in its overseas marketing efforts. "Mouse," unfortunately, translates rather poorly into Spanish. Their international packaging brightly carries a label that reads "El Raton"—the rat. ■

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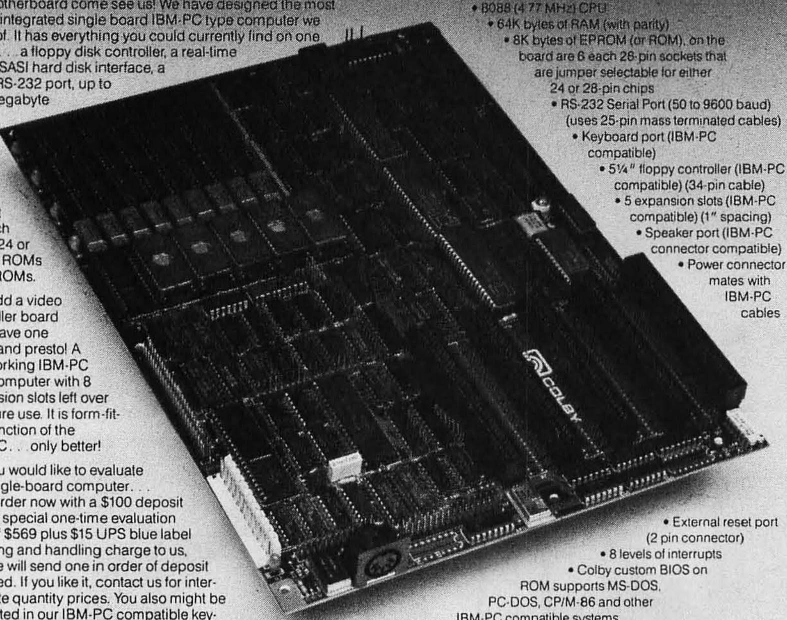

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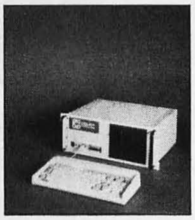

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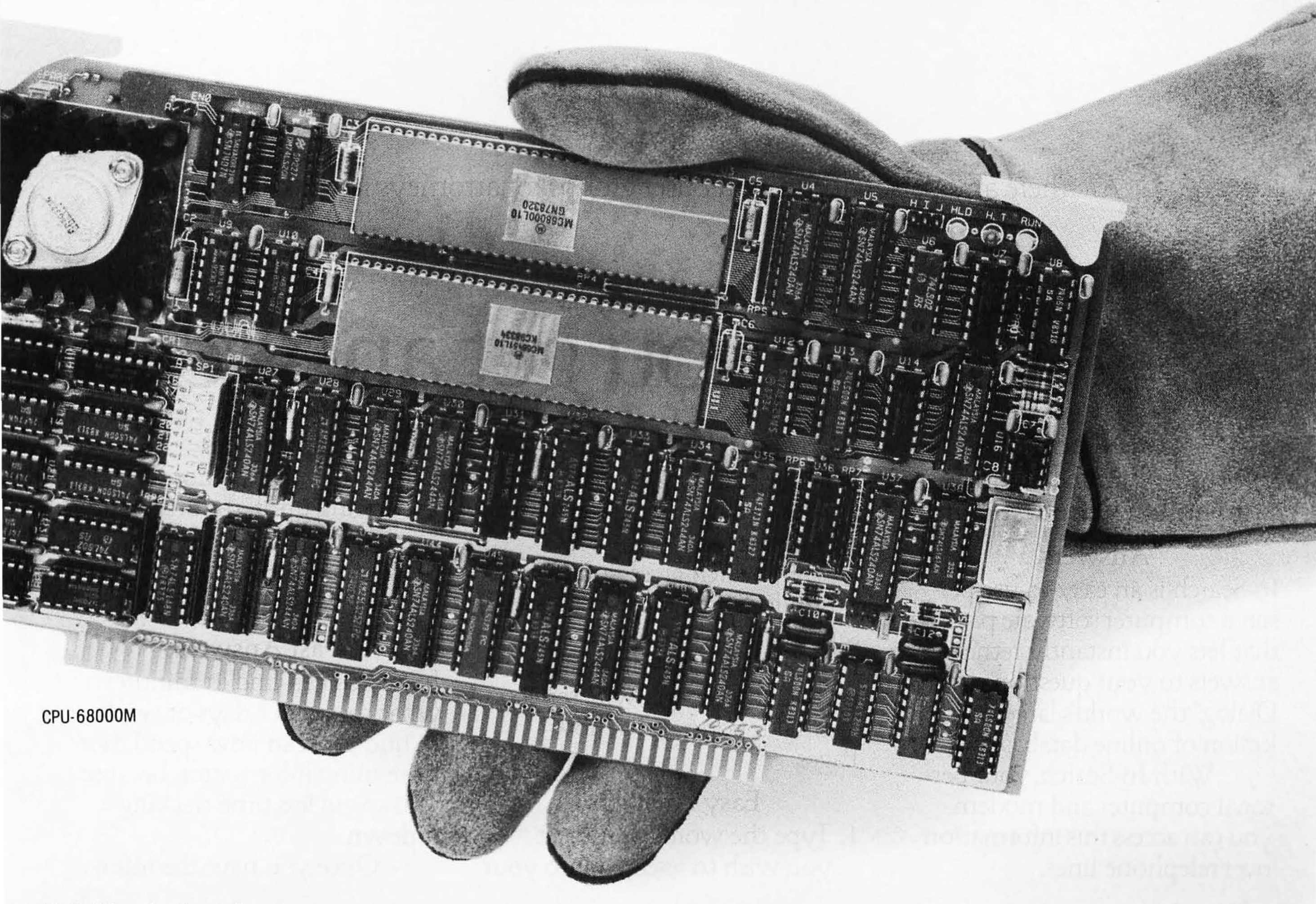

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BYTE JAPAN

Show Time

Seiko wrist terminal

Hitachi floppy disk

Sharp MZ-6500

Microfloppy systems: Fujitsu FM-77, Sony SM-777, and NEC PC-6601

Development systems

UNIX workstations

Optical filing system

BY WILLIAM M. RAIKE

As cities go, Tokyo is more hectic than most. But hectic doesn't do justice to the inspired scheduling of the 1984 Tokyo Microcomputer Show and the 1984 International Business Show, the latter featuring extensive office-automation and computer-equipment displays. *Both* of these major shows took place during the same four-day period, from May 23 through 26, and both shows were attended by what looked like a sizable fraction of the population of Tokyo, encouraged by the balmy weather and convenient (but crowded) transportation. (The trip to the Microcomputer Show involves a ride of 10 minutes or so on the monorail, which swoops southward over the warehouse district and waterfront, clipping the corners of Tokyo Bay on the way out to Haneda, the older of Tokyo's two airports.)

It seems that at any computer exhibition a handful of really innovative products are introduced, together with a greater number that represent the evolution and refinement of earlier themes. These shows were no exception: the highlights include a new wrist terminal from Seiko; a new large-capacity floppy-disk drive from Hitachi; the latest 16-bit system from Sharp; three new microfloppy-based 8-bit systems from Fujitsu, Sony, and NEC; and a large-capacity optical-disk system from Toshiba.

WRIST TERMINAL

I reported on Seiko's UC-2000 wrist computer system in the July BYTE Japan. As a reminder, that consisted of a wristwatch with an LCD (liquid-crystal display) with four rows of ten 5 by 7 dot-matrix characters and 2K bytes of CMOS (complementary metal-oxide semiconductor) RAM (random access read/write memory) for storing things like memos and phone numbers, loaded by using a small separate keyboard. Seiko also sells a personal computer interface unit, the UC-2300, which enables you to make an RS-232C connection between the watch and a conventional personal computer. The interface unit, demonstrated at the show, sells for a little over $50, about half the price of the watch/keyboard combination, and lets you upload or download data between the watch and a computer.

So much for the old stuff. Seiko chose the Tokyo Microcomputer Show for the debut of not only its new pocket LCD color television (about $380), but also the new RC-1000 wrist terminal (see photo 1). The black wristwatch/terminal has all the usual electronic watch functions (but unfortunately no calculator). The LCD consists of two rows of twelve 5 by 7 dot-matrix characters, and the on-board CMOS RAM holds 80 screens (about 2K bytes) of alphanumeric (or Japanese katakana) data.

The new wrist terminal and the older system have a number of differences; chief among them is that the new unit has a built-in RS-232C interface. It's supplied with a cable with a connector on one end that you clip onto the watch, while you plug the other end into a standard RS-232C serial connector on your computer.

In addition to storing memos and phone numbers, the watch has a world-time function besides the usual watch and alarm functions. It also has a schedule-alarm feature: the alarm sounds at any preset date and time and a corresponding screen full of data appears on the display. Along with the watch and cable, Seiko supplies downloading software for use on several of the most popular personal computer systems. The price? A little over $100.

I may be picky, but the RC-1000 wrist terminal seems to me to be *almost* a useful item. Most important, unlike the UC-2000, it has no pocket-sized keyboard for loading data, which means that it's impossible to add new memos or other information on the fly without a computer being handy. Also, the cable is only about 6 feet long. If Seiko had designed

(continued)

William M. Raike, who holds a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the United States. In 1980, he went to Japan looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer.

something like a separate portable infrared coupler instead, it would have provided a much more flexible, and slick, wrist terminal with walk-around LAN (local-area network) accessibility. The technology is certainly available, as demonstrated by the little Canon X-07 portable computer with its infrared coupler.

DISK DRIVES

Along with a lot of other people, I had been wondering just when hard-disk drives would make a noticeable impact on the personal computer scene here. This show made it more than clear that NEC and Fujitsu, the powerhouses in the upper end of Japan's personal computer market, are actively supplying hard-disk units as add-on options for their respective PC-9801 and FM-11 machines. Prices are not outrageous; for example, Fujitsu's 20-megabyte hard disk for the FM-11 (mentioned last month in BYTE Japan) lists for the equivalent of about $2150.

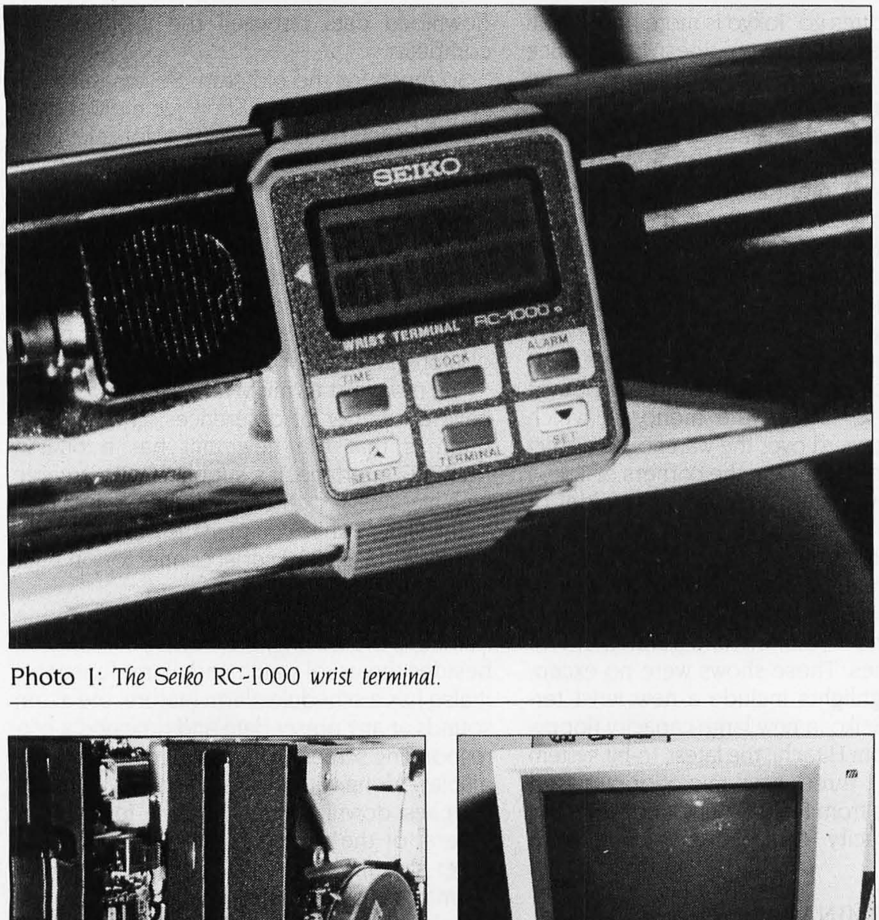

Photo 1: *The Seiko* RC-1000 *wrist terminal.*

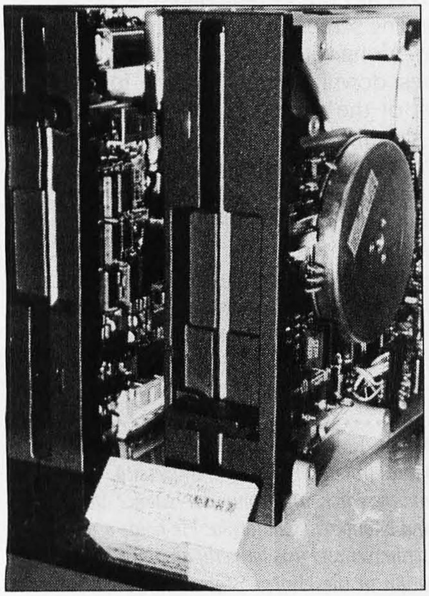

Photo 2: *Hitachi* FDD-441 9.6*-megabyte floppy-disk drives.*

Photo 3: *Sharp's* 16*-bit* MZ-6500 *system.*

It's hard to stay excited about hard disks, though, when you see something like Hitachi's new FDD-441 8-inch floppy-disk drive (see photo 2). Indistinguishable in appearance from any other thin 8-inch single floppy-disk drive, the FDD-441 manages to pack 9.6 *megabytes* (unformatted) on a single floppy. The disk format is double-sided, with a total of 308 tracks (154 tracks per side). Each track has 78 sectors with 256 bytes per sector, giving a formatted capacity of over 6 megabytes. The track-to-track time is 2 milliseconds, and the real kick is that the drive has a peak data-transfer rate of 1.5 megabits per second. A disk drive like the FDD-441 makes me think twice about investing in a hard disk when this kind of capacity is available with changeable media.

There's more. Hitachi elected to use a 5¼-inch Winchester (hard-disk) interface for the FDD-441, which means that a hard disk can be connected to the same controller, providing substantial potential savings in combined hard-/floppy-disk systems. A system with one of these drives in combination with Hitachi's DK511 5¼-inch hard disk (with a capacity of 51 megabytes unformatted or 40 megabytes formatted) would be impressive.

The FDD-441 is available now as an OEM (original equipment manufacturer) unit, but Hitachi probably will announce a separate consumer product later this year. Hitachi was a little coy about prices, but if the prices for single samples to OEMs are indicative—about $850 for the bare drive, plus about $650 for the controller—I'm getting ready to stand in line.

SHARP MZ-6500

The MZ-6500 is the newest 16-bit system from Sharp (see photo 3). (The MZ-5500 appeared in this column last month, along with the Fujitsu FM-11 BS.) The competition for 16-bit machines is tough in the Japanese market, which leads me to wonder why Sharp chose to introduce a system so similar to the

Three new 8-bit systems with 3½-inch disk drives are directed toward mid-level home computer/personal computer enthusiasts.

MZ-5500 in capabilities.

The MZ-6500 uses an 8086-2 running at 8 MHz as the main processor and incorporates an 80C49 keyboard coprocessor; standard RAM is 512K bytes, which is also the maximum. (The MZ-5500 has only 256K bytes of standard RAM.) An additional 192K bytes of video RAM is included. In order to provide complete compatibility with the MZ-5500, you can select a clock rate of 5 MHz. It has two RS-232C serial ports.

Two versions are available, one with two 5¼-inch floppy-disk drives and the other with one floppy drive and one 10-megabyte hard disk built in. The floppy-disk drive supports either a 640K-byte or a 1-megabyte format; in the 640K-byte mode it's possible to read 320K-byte disks, which provides more downward compatibility with the MZ-5500.

The software-bundling trend is appearing on the Japanese personal computer scene, although not to the extent attained in the U.S. Supplied with the MZ-6500 are the Today integrated spreadsheet/database and graphics package and a Japanese-language word processor, plus a communications support package that provides IBM bisynchronous 3270, 3780, and 3741 emulation, in addition to several flavors of BASIC. Sharp apparently decided to straddle the fence by offering both CP/M-86 and MS-DOS as standard operating systems.

The price of the MZ-6500 leads me to predict something short of a wildly enthusiastic acceptance for this system. The version with two floppy-disk drives lists for about $2800, while the version with one floppy drive and a 10-megabyte hard disk goes for about $4300. That compares with only about $1675 for the slower MZ-5500 with 256K bytes of main memory. My own choice for a 16-bit system probably will turn out to be the Fujitsu FM-11, which also sports twin 1-megabyte floppies along with a 68B09 video coprocessor, and which lists for only about $1700 with 256K bytes of RAM.

MICROFLOPPY SYSTEMS

Three new 8-bit systems that incorporate 3½-inch microfloppy-disk drives attracted considerable attention from showgoers. The Fujitsu FM-77, Sony SM-777, and NEC PC-6601 are directed toward mid-level home computer/personal computer enthusiasts, and all are being pushed to meet the growing demand for relatively inexpensive Japanese-language word processing, and to appeal to the game-playing, joystick-wielding public.

The NEC PC-6601 enjoys the advantages of NEC's top position in the Japanese personal computer industry as well as the lowest price of the three systems. Priced at the equivalent of about $600, this 64K-byte machine is based on NEC's μPD-780C-1 microprocessor, equivalent to the Z80, with an 8049 coprocessor. It has one 3½-inch microfloppy-disk drive built into the keyboard unit, providing 143K bytes of disk storage, operating under NEC's N_{66}-BASIC. The Japanese kanji character support is good, with a standard character set of 1024 characters and the full JIS (Japanese industrial standard) 3000-plus character set available as an option. A two-octave voice synthesizer/music generator is standard and is supported by 16K bytes of ROM (read-only memory). Color graphics capabilities are good, and an optional RS-232C interface is available.

Sony offers the SMC-777 (and the SMC-777C, with added color graphics features). The main processor is a Z80A, with an 8041 subprocessor and 64K bytes of RAM standard. The built-in

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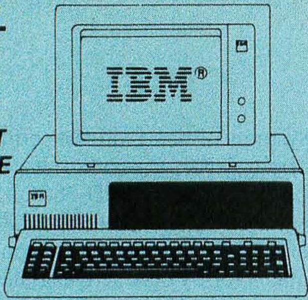

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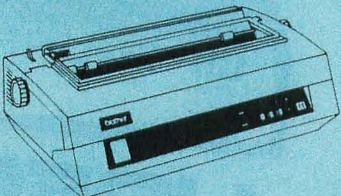

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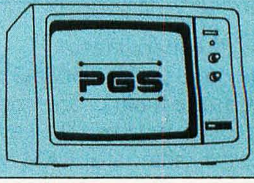

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microfloppy-disk drive has a 280K-byte capacity. This machine also can incorporate color graphics capabilities and a music generator. Surprisingly, no serial interface is available. The list price of the SMC-777 is about $625.

One extremely attractive feature of the SMC-777 is that the operating system, called Sony Filer, is compatible with CP/M 1.4. In addition to BASIC, an assembler, debugger, and basic utilities, the system is supplied with a simple filing package called Memo and with Dr. Logo, Digital Research's version of the Logo language. Software options include SuperCalc, English and Japanese word processors, games, and several graphics packages, and Sony has announced that SMC versions of FORTRAN, COBOL, Pascal, and C will be available. (But they haven't said when.)

Fujitsu's entry in the microfloppy-system realm is the FM-77. Priced at about $850 for a one-drive version and $980 for a two-drive version, the FM-77 offers a number of features present on neither the Sony nor NEC machines, notably 320K-byte microfloppy-disk drives, RAM expandability up to 256K bytes (64K bytes is standard) plus 48K bytes of video RAM, full Japanese kanji character support, and availability of an extensive range of option cards, including Z80, RS-232C, 1-megabyte minifloppy-disk interface, high-resolution (400-line) graphics, and voice input cards. A mouse also is available.

The FM-77 uses an MBL68B09, running at 2 MHz, as the main processor; the optional Z80 runs at 4 MHz and is supplied with CP/M-80 on a 3½-inch microfloppy-disk drive. Another MBL68B09 is used as a coprocessor (running at 2 MHz) for handling both keyboard and display-management chores in order to lighten the load on the main processor. The standard operating system is OS-9, a UNIX-like multiuser, multitasking operating system usually found on much more powerful systems. The FM-77 also is supplied with Fujitsu's versions of Logo and BASIC.

Unlike both the NEC and Sony machines, which incorporate their microfloppy-disk drives in the keyboard unit, the FM-77 has separate keyboard and processor/disk-drive units due to Fujitsu's desire to provide a two-drive version and due to the space needed to accommodate the option cards most users will undoubtedly install.

ETC.

Space doesn't permit me to say very much about the hundreds of other features at the show. There was a plethora of microprocessor development systems (as I recall, one plethora = 0.3846 baker's dozen), including the BOX development system, PROM (programmable read-only memory) programmer and in-circuit emulator/debugger for both 8- and 16-bit systems, and the portable DUX Integral development system. The cost of these and other development systems indicated that the price of these tools is descending steadily.

I saw several UNIX workstations in the 8- to 16-kilobuck range, notably the Omron Super Mate and the Toshiba UX-300F. Toshiba also showed a large-capacity optical filing system, the Tosfile 3200, at the Business Show; the system stores up to 60,000 pages (3.6 *giga*bytes) of extremely high quality (8 dots per square millimeter) picture information on optical disks. It incorporates a CCD (charge-coupled device) scanner and electrostatic laser printer, and it permits rapid document input and indexing as well as quick hard copy of the screen contents. It has RS-232C and IEEE-488 interfaces and supports facsimile transmission, with a high-speed facsimile interface to be available in the future.

Software vendors were there in force; the Japanese software industry, still comparatively infant, shows signs of maturing in a hurry.

COMING UP

Stay tuned for information about the NEC PC-8801 MkII and PC-100 systems, a new portable printer/typewriter from Brother, and a revealing interview with Casio about its decision *not* to sell its 16-bit FP-6000 system in the U.S. ■

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BYTE U.K.

The Sinclair QL

A first look at this 68008-based premature baby

BY DICK POUNTAIN

For centuries, commentators in other lands have been trying to identify an "English disease" (or sometimes "vice"). The diagnosis has moved, during the latter half of this century, away from flagellation and toward excessive industrial striking and unrest. However, I would like to propose a new candidate, the premature announcement of personal computers.

The U.S. personal computer industry does not have an altogether unblemished record; for instance, the Coleco Adam had a difficult birth, as documented in BYTE (April, page 206). But compared to the U.K. scene, that is nothing.

In 1981, Britain had Acorn's BBC Computer; some mail-order customers waited a year for the goods to arrive. Shortly afterward, Sinclair's Spectrum took a good six months to reach full production and went through traumas that resulted in smoking power supplies, recalled machines, and redesigned main boards.

Last year the U.K. witnessed the announcement of the Elan Enterprise, an ambitious design with 256-color graphics, ANSI (American National Standards Institute) BASIC, and a Z80 with a paged 128K bytes of RAM (random-access read/write memory). Delivery was to be May '83, then September '83, now September '84. But Elan did have the grace not to release it half-finished.

British home-computer manufacturers have stumbled upon a whole new manufacturing algorithm that I've summed up in the pseudocode shown in listing 1. (For any U.K. lawyers reading this listing: It's a joke, a funny, okay?)

All of this is by way of preamble to a rundown on Sinclair Research's new QL (Quantum Leap), which I've just managed to get my hands on (see photo 1).

Sinclair Research announced the QL in January of this year, just a week before Apple unveiled the Macintosh. Most observers here agree that the launch was timed to take some of the wind out of Apple's sails, for the QL features a 68008 processor, built-in mass storage, 128K bytes of RAM, and a suite of application programs for £400, whereas Mac is going to sell at nearer £2000 here.

Delivery was quoted as 28 days from the announcement. To no one's surprise (we do learn, if slowly) the machine was not delivered in 28 days; the first models finally emerged in April. By the end of May, rumor had it that some 300 or so machines had been delivered to mail-order customers, and it's one of these that I've tested. The waiting list, according to spokespeople at Sinclair, stands at around 13,000.

QL OVERVIEW

So what's the QL like? The question actually should be phrased "what will it be like?" because the machines currently being delivered are far from complete. Significant parts of the operating system are missing, and what operating system there is Sinclair has partly housed in a plug-in EPROM (erasable programmable read-only memory) because it won't all fit into the onboard ROM sockets. By the time you read this, though, Sinclair says that QDOS will be complete and that early customers will have a free upgrade to the onboard ROM version (and a free RS-232C cable by way of compensation).

The QL is packaged as a console unit that contains the processor and all electronics, the keyboard, and two Sinclair Microdrives in a box about the size of an IBM PC keyboard. The power supply is in a separate box, and you must add either a domestic PAL (phase alternate line) TV or an RGB (red-green-blue) monitor for display.

The keyboard looks very smart, with futuristic round, dished keys (like the NCR). Previous Sinclair computers had either membrane keyboards or the horrid rubber keys of the Spectrum, so this is a step forward. However, under those smart keytops lurks—a *rubber* membrane keyboard. I find the feel dead and unresponsive, while the space bar and carriage return keys have a tendency to stick if not hit squarely.

Microdrives are Sinclair's version of the

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"stringy-floppy" theme and were first introduced a year ago for the Spectrum. They differ from previous stringy-floppy designs mainly in their physical size; the tape cartridges are slightly smaller than those microcassettes used in pocket dictating machines and are filled with a 200-inch continuous loop of 2-millimeter wide video-quality tape. That's how two drives can fit into a space that would not accommodate one 3-inch floppy-disk drive.

The media hold around 100K bytes each, formatted in 512-byte sectors. The operating system performs error-checking whenever a cartridge is formatted and locks out any bad sectors, so the capacity gradually decreases with age. As for speed, the loop takes about seven seconds for a round trip, so this is the maximum seek time to find a sector—much slower than a floppy-disk drive, but very much faster than audiocassette (most U.K. home-computer buffs still use cassettes). When the Spectrum Microdrives were first shipped, tape friction led to an excessive wear rate and a short media life. Sinclair claims that better tape stock and improved lubricants have cured the problem, but I had 2 out of 11 tapes go bad on me during the test period.

The QL architecture is based on the Motorola 68008, the 8-bit data bus version of the 68000. It runs at a respectable 7.5 MHz. Supplementing the microprocessor is an Intel 8049 that handles the keyboard and sound generation, while four custom ULAs (gate arrays in U.S. parlance) look after memory management, display logic, Microdrives, and serial ports. Two of these ULAs, designed by Ferranti, are hybrid digital/analog devices (trade-name Digilin) that perform motor-speed and signal-level control for the Microdrives.

Listing 1: *The new British manufacturing algorithm.*

```
PROC New Home Computer IS
      Announce Product
      Announce Delivery Date
      Collect Customers' Money
      IF sufficient interest THEN /* pun intended */
         Design Product
         Manufacture Prototypes
           REPEAT
             Ship to customers
             Record complaints
             Fix bugs
           UNTIL it works
          Sell it to W.H. Smiths /* U.S. readers substitute any large retailer */
      ELSE file for bankruptcy
       ENDIF
END PROC
```

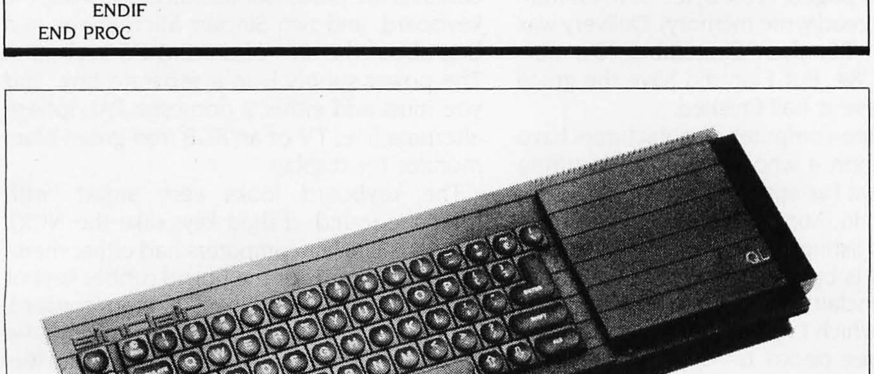


Photo 1: *The Sinclair QL.*

The standard memory complement is 128K bytes (in 64K-bit chips), but there is provision for a future 512K-byte expansion module.

The QL is well equipped with I/O (input/output), though it has no parallel printer socket. There are two RS-232C connectors, one wired as DCE (data communications equipment) and the other as DTE (data terminal equipment), and two jack sockets for Sinclair's twisted-pair network, which is not yet implemented. A bus extension socket lets you plug in ROM-cartridge software, but it's permanently occupied by the overspill operating system ROM on the early machines. An edge connector at the Microdrive end of the case lets you connect up to six more Microdrives (and possibly a Winchester drive later).

Color graphics are memory-mapped, with a maximum resolution of 512 by 256 pixels or 80 text columns; in this mode only four colors (red, green, white, and black) are available. In the half-resolution mode, 40 columns and eight colors are available (adding cyan, magenta, yellow, and blue). Also, an intermediate text mode has 64 columns.

Text size is variable through software switching, providing character widths of 6, 8, 12, or 16 pixels and heights of 10 or 20 pixels, which allows big letters and a variety of condensed letters. The single typeface is provided by a character generator rather than the Macintosh/Lisa soft raster graphics approach.

The eight colors are supplemented by a large number of "stipples," which consist of a plain background color with horizontal or vertical stripes or checks in a second color. The stipples are too coarse to give the appearance of true tints, but they're quite attractive in their own right. In short, the color choice on the QL is fairly restricted compared to many of the more recent home machines—for example, the Commodore 64 or MSX machines—though the resolution available is better than most.

The graphics commands available through SuperBASIC are quite rudimentary; the QL has no sprites or other hardware assistance, and only the simplest *point-, line-, and* circle-drawing routines.

The QL operating system, QDOS,

does provide direct support for screen windows, though. The operating system is channel oriented—all the physical devices are treated as files to which you assign one of 16 channels for communication. When you open a channel to the console or screen device, part of the file specification is the size window required, along with the amount of type-ahead buffer to allocate. This makes it very easy to open several different channels to different screen windows and redirect output to them using the standard I/O commands (PRINT # n sends its output via channel n). Windows can overlap each other but QDOS doesn't do anything about restoring the contents of overlapped windows; they're lost for good unless the application does something about saving them. Built-in PAN and SCROLL commands let you manipulate windows, with the same proviso that their contents are not buffered and will be lost if they leave the window.

The hot promise of QDOS is multitasking, but unfortunately this feature is not ready yet and wasn't working on the machine I used. It will work on a process model, creating a separate process for each of a number of programs to be run in parallel. Combined with the windowing, this could permit some serious integration of applications. QDOS will directly handle communication between processes using pipelines.

SUPERBASIC

SuperBASIC is a great improvement over previous Sinclair BASICs, which were highly nonstandard. Most important, it has an excellent set of structured control constructs that make it a much better educational aid than its predecessors.

SuperBASIC procedures support full parameter passing, as well as multiline function definitions (with RETURN used to assign the result rather than assignment to the function name). IF. . .THEN. . .ELSE. . .ENDIF also is multiline and is complemented by SELECT ON, a variant of the Case construct, with a proper default clause called REMAINDER.

Two nicely symmetrical constructs do looping: FOR. . .END FOR and REPEAT. . .END REPEAT. Both of these use a loop identifier to clarify nested loops, allow premature exits with EXIT, and use NEXT to force an immediate repetition (FOR is a counted loop and REPEAT is unbounded). They both have a single-line short form that requires no END statement, and these short forms allow neat coding of common operations such as filling an array or waiting for a keypress. The icing on the cake is that identifiers can be of any length (up to 255 characters) and all characters are significant.

SuperBASIC is very, very slow. With a 7.5-MHz 68008, you'd think it would take some effort to run that slowly.

Proper use of all these constructs gives programs a very clean, almost Pascal-like appearance; line numbers still are required but should be irrelevant except as references for editing.

SuperBASIC supports string, integer, and single-precision floating-point data types, along with the novel (for BASIC) idea of automatic "coercion." This means that, if possible, SuperBASIC will force data types into expressions of a different type, letting you, for example, add a string to an integer:

```
123 + "456"
```

This will give the answer 579, because you've coerced the string into an integer. Serious devotees of structured programming will be appalled by this liberty, which is the antithesis of strong typing. Other schools of thought, though (like the Logo community), will sympathize with the quest for an untyped language. Coercion doesn't go all the way—you can't assign a string to a numeric variable unless the string is the representation of a number, so LET A = "WOW!" fails.

A big problem with SuperBASIC is that it's very, very slow. Part of the problem is that, at present, the index of a FOR loop is coerced to floating point, when using integer would be much faster. This might change in later versions. I ran the Sieve of Eratosthenes benchmark in SuperBASIC using both FOR and REPEAT loops with an integer count. The timings came out at 4480 and 5300 seconds, respectively, which puts SuperBASIC right down at the bottom of the BYTE hit parade. With a 7.5-MHz 68008, you'd think it would take some effort to get a language to run that slowly. Sinclair will be working on the problem and later versions should be better.

Another drawback for business users is that the single-precision arithmetic only has seven-digit accuracy, which is not enough for serious cash programs. Oddly, it supports an enormous dynamic range of $10^{\pm 613}$ so you can represent numbers far larger than the number of quarks in the universe, but not the pennies on your balance sheet if your turnover exceeds £99,000.

SUPPLIED SOFTWARE

The QL comes with four bundled application software packages. Supplied on Microdrive cartridges, these were written by Psion, the U.K. software house that was previously better known for its Spectrum games. The four programs are the Quill word processor, Abacus spreadsheet, Archive database manager (dbm), and Easel business graphics. All four share a common user interface format that makes them collectively easier to learn. You select commands from pull-down menus by typing the first character of the name. As much as possible, the function keys have similar uses in all the programs. For instance, function key F1 always retrieves on-line, context-sensitive help, while F3 pulls down the command menu.

The applications are not integrated; the multitasking operating system was not ready when Psion was developing them. You have a limited ability to transport data files among them—the database can import from the spreadsheet or graphics packages and export to all the others, for example.

Quill is a neat little editor in the what-you-see-is-what-you-get mold. It includes all the basics and few frills. You can see superscripts and subscripts in place on the screen, with boldface type shown in a different color. The screen automatically is reformatted with

(continued)

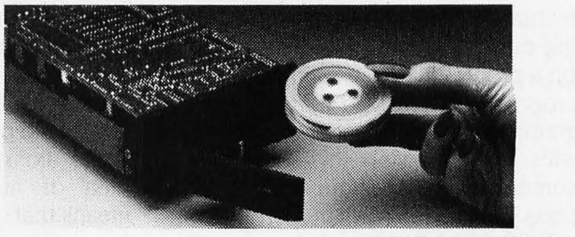
reverse word-wrap, so you can indent a paragraph or alter the margins by merely "pushing around" the text with the cursor. Quill works in 40-, 64-, or 80-character modes so you can use it on a domestic TV in an emergency. The main limitation of Quill is that it doesn't use virtual memory, so the largest document you can edit is what will fit into RAM. Surprisingly, it doesn't support split-screen windows.

Archive is a powerful dbm program that certainly is no toy. It incorporates an interpreted programming language with the same structured features as SuperBASIC but with ultrahigh-level verbs to do searching, sorting, inserting records, etc. The program is menu driven from a series of menus that are cleverly graded so a first-time user only needs to use the first one that appears after boot-up. To such a user, Archive appears to be a non-programmable menu-driven package. As you gain experience, you can move on to the later menus that contain the programming-language commands. You can use a built-in structure editor to write procedures that you can add to the menus to extend the range of commands.

The vital statistics of Archive are quite grown-up too; you can open up to 255 files simultaneously (on a 100K-byte Microdrive!), each with up to 64,000 records (variable length) of up to 255 fields of up to 255 characters. You can use a second built-in editor to design input and output forms based on an interactive "paint-a-screen" approach. Again, a first-time user doesn't have to take advantage of this sophistication but can use the defaults provided to produce simple card-index applications.

Abacus is a quite orthodox spreadsheet that lacks the more advanced features of Lotus 1-2-3 and Multiplan, though it does have some niceties of its own. For instance, you can use a built-in function to set up columns with month headings, give names to columns and rows, and reference cells by a pair of names in expressions (for example, sales:region2, which is more meaningful than A12 or R2:C9).

Easel is the sexiest of the programs by a long chalk. It's a fully interactive graph-plotting system that accepts data straight from the keyboard or loaded from a file. The user interface is superb: You use a pair of cross hairs, like those in expensive CAD/CAM (computer-aided design/computer-aided manufacturing) systems, to position objects and text. Easel is auto-scaling, so data always fits on the screen. The program has a large variety of different graph formats and colorings, and you choose them from a "shop window" of samples rather than from some dry menu. It's too limited for scientific use (no logarithmic scales, the *x*-axis always must be in even time periods, etc.), but it produces very professional business charts and is easier to use than just



about anything I've seen.

Taken all together, these applications cover most simple business needs, and they're very well designed. Indeed, Psion has plans to launch the whole bundle, fully integrated under a custom-written multitasking executive, for the IBM PC and MS-DOS systems.

Look Before You Leap

What's the overall verdict on the QL? Sinclair created a furor over here when it announced the QL; business folks who had resisted purchasing anything so far thought that they were going to get a first-class business system for a song, while the truly serious hackers were drawn to a 68000 as if by a magnet.

At £400, with usable software and mass storage thrown in, the QL certainly looks like a good buy for impoverished business users. How satisfied those users will be depends upon the long-term reliability of the Microdrive media (the signs are not encouraging); the keyboard is not going to win any friends either, when businessmen have to use it for eight hours a day. Sinclair has hinted that it plans to skip over the floppy-disk drive altogether and go straight to a mini-Winchester as the QL's upgrade path. Whether this would put a tiger in its tank or not depends on whether the extremely disappointing performance figures achieved so far are a real reflection of the chip's capabilities.

For the serious hobbyist, it's another matter. The QL costs the same as the (in my opinion, wildly overpriced) BBC Model B with its 6502 and 32K bytes of user RAM; and Microdrives beat the heck out of cassettes.

I have to confess to a certain technical disappointment though, both with the emasculated version of the 68000 and with the relatively uninspired systems software. A rival to Macintosh this is not, but then, you get what you pay for. Also, who's to know how the QL will perform once Sinclair finishes it and once the third-party software mob gets hold of it? A game that is popular over here at the moment, called 3-D Ant Attack, features full-color, animated, 3-D perspective graphics and runs fast as heck on a *48K-byte Spectrum*. And what about Pinball Construction Set on the creaky old Apple. . .? ■

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new commands for Uservoc. Taken together, you can use the four vocabularies to create any sort of application you can imagine, all the way to new languages (FORTH has been used to write a BASIC interpreter; such a job is well within the power of KAMAS).

You enter programs as text in "leaves" of the KAMAS outline tree; should a program require more space than a single leaf, it can call a subsidiary leaf. The job execution facility, Jex, tells KAMAS to run the program.

To illustrate the language's power, the distribution disk contains a sampling of utilities written in KAMAS. One utility is a full electronic bulletin-board system that works with a D.C. Hayes Smartmodem set up to use the KAMAS outline-processing capabilities as a message center. Another program (see listing 1) gives a dump of RAM (random-access read/write memory) in both hexadecimal and ASCII (American National Standard Code for Information Interchange). Other utilities include a date-stamping system to attach a time of creation to each new leaf added to the tree, a topic copy utility, and a program debugger.

Outline processing might be the next wave in software, and KAMAS *is a good place to start.*

Listing 1: *A program written in the* KAMAS *programming language that displays* RAM *contents in hexadecimal and* ASCII. *Though* KAMAS *bears a resemblance to the structure and stack orientation of* FORTH, *the vocabulary is unique and the syntax does not follow* FORTH *conventions.*

```
MDUMP — Utility to dump memory in hexadecimal

LANG SYS
; Just Jex this leaf to define the MDUMP command
;   eg:  0 100 MDUMP dumps the first 100 bytes of RAM
;
'I  :WOVAR
;
'BOOUTH  :  CHECKMOD RADIX SWAPW WOCVTDI SETHEX SPOUT
     FMT DIGIT DIGIT .FMT
     STOUT TO RADIX .
;
'WOOUTH  :  CHECKMOD RADIX SWAPW WOCVTDI SETHEX SPOUT
     FMT DIGIT DIGIT DIGIT DIGIT .FMT
     STOUT TO RADIX SPOUT .
;
'DUMP8  :  7 0 COUNT DUPW 1WO WO+ FETB BOOUTH .COUNT DROPW SPOUT .
;
'PRTCHR?  :  DUPW 32 WO SWAPW 126 WO WOR .
;
'ADUMP8  :
     7 0 COUNT
         DUPW 1WO WO+ FETB DUPW PRTCHR?
             IFSO DROPW  '. ASCII .IFSO
         WCOUT
     .COUNT
     DROPW SPOUT .
;
'DUMPLINE  :
     NEWLINE DUPW WOOUTH DUPW
     DUMP8 DUPW 8 WO+ DUMP8 SPOUT
     DUPW ADUMP8 8 WO+ ADUMP8 .
;
'ALIGN  :
     SWAPW 16 WO/ 16 WO*
     SWAPW 16 WO+ 16 WO/ 16 WO* .
;
'MDUMP  :                        ; (woaddr wolen --- )
      ALIGN WO1– 0 1 FOR I +WODO
        DUPW I WO+ DUMPLINE 15 +TO I
      .WODO  DROPW .
```

A BRIEF EVALUATION

KAMAS has a very strong personality. It is not a pretty program, as it lacks many of the display characteristics and user-friendly niceties of the current crop of programs for the IBM PC. Its command structure offers a diversity of modes that can be confusing to a novice, and even an experienced user will have to take some time to figure out a comfortable way to work within the constraints of a strict hierarchy.

KAMAS also is largely a closed system—it can dump its text to the operating system as straight ASCII, but it cannot incorporate data produced with other application programs unless you write a utility to do so. The programming language is unlike any other; programs do not follow an English-like syntax, nor do they share much more than a stylistic resemblance to other threaded languages—the new vocabularies are alien even to the proficient FORTH user.

Yet KAMAS is without question an interesting addition to the world of CP/M software, and one capable of performing real work. It is one of the first—if not the first—outline processors for Z80 computers, which have been neglected by software developers in the past year or so. Outline processing might be the next wave in software, and KAMAS is a good place to start. Its language is certainly flexible and powerful, if difficult to learn. In short, KAMAS might not be for everyone, but its potential as an organizing and programming tool for serious users—who can work with its idiosyncrasies—is indisputable. ■

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or measuring, you can see that the two closest points are the TI99/4A (hereafter just TI99) and the TRS-80 Color Computer (CoCo). These are used next to create a new point, called (TI99,CoCo), halfway between (figure 2b). Now there are only two points, and they are simply connected to give one all-embracing point, namely ((TI99, CoCo), Atari) (figure 2c). I've positioned this point closer to (TI99, CoCo), since it is composed of two other points and the "Atari" point is a single point. In other words, the new coordinates (step 3 of the algorithm) are a weighted average, and each point is given a weight equal to the number of simple points that it contains.

In figure 2d, a dendrogram has been drawn for this small example. The names of the points are listed in the same order as in the final composite name. It turns out that this order does the best possible job of avoiding crossed lines in the final dendrogram. Horizontal lines are drawn of the same lengths as those between the points (labeled d_1 and d_2) and connected to produce the dendrogram.

THE LINKED LIST

It's probably clear by now why data of this type is easily handled in the form of a linked list. For cluster analysis, the algorithm says that each point is made up of only two other points at a time, so a binary linked list will do. In a binary linked list, each item (what I've been calling "points"—also called "nodes") has three pointers associated with it: one "above" to the next more complex node, and two "below" to the two nodes that it contains. In this spirit the *i*th node in listing 1 has pointers *A*(*i*) for "above" and *B*1(*i*) and *B*2(*i*) for "below." Each node also has its coordinates *X*(*i,k*), its weight *W*(*i*), and its name *NN$*(*i*).

The linked list is built in lines 400-730 in a straightforward application of the algorithm. The distance between a pair of nodes is calculated in lines 450 and 460 as the square of the geometric (or Euclidean) distance. The weighted average coordinates of the new node are calculated in lines 520-540, its weight in line 550, and its name—a concatenation of strings with the parenthesis and comma convention used in

(continued)

Listing 1: *The cluster-analysis program in Microsoft* BASIC.

```
10 ' cluster analysis
20 '    Rob Spencer
30 '
40 CLEAR 2000
50 DEFINT A-C,I-N
60 READ NV,NP
70 NM=2*NP
80 DIM X(NM,NV),W(NM),XS(NV),XM(NV),X2(NM)
90 DIM B1(NM),B2(NM),A(NM),NN$(NM)
100 DIM PX(NM),PY(NM)
110 '
120 '   read data , do sums and sums of squares
130 '
140 FOR K=1 TO NV:XS(K)=0:XM(K)=0:NEXT K
150 FOR I=1 TO NP
160   W(I)=1
170   FOR K=1 TO NV
180      READ X(I,K)
190      XM(K)=XM(K)+X(I,K)
200      X2(K)=X2(K)+X(I,K)^2
210   NEXT K
220   READ NN$(I)
230 NEXT I
240 '
250 '   do means and standard deviations
260 '
270 FOR K=1 TO NV
280  XS(K)=SQR((X2(K)-(XM(K))^2/NP)/(NP-1))
290  XM(K)=XM(K)/NP
300 NEXT K
310 '
320 'convert data to normal form
330 '
340 FOR I=1 TO NP
350  FOR K=1 TO NV:X(I,K)=(X(I,K)-XM(K))/XS(K):NEXT K
360 NEXT I
370 '
380 '   build linked list
390 '
400 N0=NP : NC=NP
410 DMIN=1E+06
420 '                   find the closest pair of nodes
430 FOR JP=2 TO NC
440    FOR IP=1 TO JP-1
450       D=0
460       FOR K=1 TO NV:D=D+(X(IP,K)-X(JP,K))*(X(IP,K)-X(JP,K)):NEXT K
470       IF D<DMIN THEN DM=D:I=IP:J=JP
480    NEXT IP
490 NEXT JP              ' nodes i and j are closest
500 '
510 NP=NP+1              ' combine i and j, add to the bottom of the list
520 FOR K=1 TO NV
530    X(NP,K)=(W(I)*X(I,K)+W(J)*X(J,K))/(W(I)+W(J))
540 NEXT K
550 W(NP)=W(I)+W(J)
560 NN$(NP)="("+NN$(I)+" , "+NN$(J)+")"
570 '
580 '            swap the new node into list, old i and j out
590 FOR K=1 TO NV
600    SWAP X(I,K),X(NP,K)
610    SWAP X(J,K),X(NC,K)
620 NEXT K
630 SWAP B1(I) ,B1(NP)      :SWAP B1(J)      ,B1(NC)
640 SWAP B2(I) ,B2(NP)      :SWAP B2(J)      ,B2(NC)
650 SWAP W(I) , W(NP)       :SWAP W(J)       ,W(NC)
660 SWAP NN$(I),NN$(NP)     :SWAP NN$(J)     ,NN$(NC)
670 B1(I)=NC                :B2(I)=NP
680 '
690 PRINT DM,NN$(I)
```

(continued)

the discussion of figure 2—in line 560.

After creating a new node by combining nodes *i* and *j*, we don't really want to "discard" the separate nodes *i* and *j*, since they'll be needed to draw the dendrogram. They are therefore swapped with nodes at the bottom of the list (lines 590-670) and removed from further clustering by decrementing the counter *NC* (lines 720,730).

RECURSIVE SUBROUTINES

The program has four separate recursive subroutines, beginning at lines 1060, 1120, 1200, and 1310. Each subroutine does a single task and is entered only once from the main part of the program. I'm sure there are more compact ways to do these tasks, but the recursive subroutines are fun to experiment with and difficult enough to decipher without combining their functions.

Two aspects of the linked list make recursive exploration of the list easier. First, there is always a simple entrance: the first node in the list will always be the most composite node, the one at the far right in figures 1 and 2d. This is also known as the root node. Table 1, which is a printout from the program (with LPRINTs instead of PRINTs in lines 810-840), shows this. Second, there is a simple exit from recursion: the simplest nodes (at the far left in figures 1 and 2d) all have zero values for their pointers *B*1 and *B*2.

Note that the subroutines have a common structure that involves frequent resetting on the variable CP. This stands for "current point" and is the index needed to follow the linked list from node to node. The general form of the subroutines is written out in figure 3 in an expanded, heavily commented BASIC. It's worth following the recursive routine of figure 3 through part of the linked list (table 1) to see how the branches are traversed. A PRINT statement within a recursive subroutine is helpful. For instance, adding the following line:

1135 PRINT *CP, NN$(CP)*

will show the current point as it moves through the list. Another way to visualize the workings of one of the subroutines is by inserting the statement PRINT "push" at the very begin-

```
700 '                count down; if not done, find the
710 '                     next closest pair of nodes
720 NC=NC-1
730 IF NC>1 THEN GOTO 410
740 '
750 '     set the A pointers by recursion
760 '
770 CP=1:GOSUB 1060
780 '
790 '     print the linked list
800 '
810 PRINT:PRINT"          pointers"
820 PRINT"   i   B1   B2   A":PRINT
830 FOR I=1 TO NP
840    PRINT USING" ## ";I,B1(I),B2(I),A(I);:PRINT"    ";NN$(I)
850 NEXT I
860 '
870 '     build the dendrogram
880 '
890 Y=-1
900 CP=1:GOSUB 1120         ' set coordinates by
910 CP=1:GOSUB 1200         '      recursion
920 '
930 DEF FNPX(I)=100*PX(I)/PX(1)+30   '  machine specific
940 DEF FNPY(I)=90-90*PY(I)/N0       '       functions
950 PX(0)=1.05*PX(1)
960 PRINT CHR$(12)     '  clear screen and draw dendrogram
970 CP=1:GOSUB 1310
980 LOCATE 0,23        ' put the cursor out of the way
990 END
1000 '
1010 '------------------------------------------------------------
1020 '  recursive subroutines
1030 '------------------------------------------------------------
1040 '  set upward pointers A(i)
1050 '
1060 IF B1(CP)>0 THEN A(B1(CP))=CP:CP=B1(CP):GOSUB 1060:CP=A(CP)
1070 IF B2(CP)>0 THEN A(B2(CP))=CP:CP=B2(CP):GOSUB 1060:CP=A(CP)
1080 RETURN
1090 '
1100 '     set Y coord's of simple nodes
1110 '
1120 IF B1(CP)>0 THEN CP=B1(CP):GOSUB 1120:CP=A(CP)
1130 IF B2(CP)>0 THEN CP=B2(CP):GOSUB 1120:CP=A(CP)
1140 IF B1(CP)>0 THEN RETURN
1150    Y=Y+1:PY(CP)=Y:PX(CP)=0
1160 RETURN
1170 '
1180 '     set X and Y coord's of other nodes
1190 '
1200 IF B1(CP)>0 THEN CP=B1(CP):GOSUB 1200:CP=A(CP)
1210 IF B2(CP)>0 THEN CP=B2(CP):GOSUB 1200:CP=A(CP)
1220 IF B2(CP)=0 THEN RETURN
1230    D=0:I=B1(CP):J=B2(CP)
1240    FOR K=1 TO NV:D=D+(X(I,K)-X(J,K))^2:NEXT K
1250    PY(CP)=(W(B1(CP))*PY(B1(CP))+W(B2(CP))*PY(B2(CP)))/(W(B1(CP))+W(B2(CP)))
1260    PX(CP)=SQR(D)
1270 RETURN
1280 '
1290 '     draw dendrogram
1300 '
1310 IF B1(CP)>0 THEN CP=B1(CP):GOSUB 1310:CP=A(CP)
1320 IF B2(CP)>0 THEN CP=B2(CP):GOSUB 1310:CP=A(CP)
1330    LINE(FNPX(CP) ,FNPY(B1(CP)))-(FNPX(CP),FNPY(B2(CP))),PSET
1340    LINE(FNPX(CP),FNPY(CP))      -(FNPX(A(CP)),FNPY(CP) ),PSET
1350    IF B1(CP)>0 THEN RETURN
1360    LOCATE 2,FNPY(CP)/4
1370    PRINT NN$(CP);
1380 RETURN
1390 '
1400 '------------------------------------------------------------
1410 '
1420 DATA 9,12
```

(continued)

```
1430 '                              data are
1440 ' software, MS-DOS, RAM, disk, keypad, fn keys, columns,
1450 ' portable, price
1460 '
1470 DATA 2, 0,  64, 140, 1,  0, 80, 0, 2058  ,Ace
1480 DATA 0, 0,  64, 140, 0,  0, 80, 0, 1919  ,Apple IIe
1490 DATA 0, 0,  48,   0, 0,  0, 38, 0,  470  ,Atari 800
1500 DATA 0, 0,  64,   0, 0,  4, 40, 0,  293  ,Comm 64
1510 DATA 0, 1, 128, 320, 1, 10, 80, 1, 3010  ,Compaq
1520 DATA 0, 1,  64, 180, 1, 10, 80, 0, 2558  ,IBM PC
1530 DATA 3, 0,  64, 195, 1,  0, 80, 1, 1600  ,Kaypro II
1540 DATA 2, 0,  64, 204, 1,  0, 80, 1, 1250  ,Osborne I
1550 DATA 0, 0,  16,   0, 0,  0, 28, 0,  205  ,TI 99/4A
1560 DATA 0, 0,  16,   0, 0,  0, 32, 0,  385  ,TRS Color
1570 DATA 0, 0,  64, 184, 1,  3, 80, 0, 1700  ,TRS 80-4
1580 DATA 0, 0,   5,   0, 0,  4, 22, 0,  193  ,Vic 20
```

Table 1: *The linked list as generated by listing* 1.

	pointers			
i	B1	B2	A	
1	2	23	0	(((((Ace,TRS 80-4),Apple IIe),(Kaypro II, Osborne I)),(((Atari 800,(TI 99/4A, TRS color)),Vic 20),Comm 64)),(IBM PC, Compaq))
2	4	21	1	(IBM PC,Compaq)
3	8	17	23	(((Atari 800,(TI 99/4A,TRS Color)),Vic 20),Comm 64)
4	0	0	2	Compaq
5	11	14	22	(Kaypro II,Osborne I)
6	0	0	20	Apple IIe
7	0	0	19	TRS 80-4
8	0	0	3	Comm 64
9	0	0	17	Vic 20
10	12	13	16	(TI 99/4A,TRS Color)
11	0	0	5	Osborne I
12	0	0	10	TRS Color
13	0	0	10	TI 99/4A
14	0	0	5	Kaypro II
15	0	0	16	Atari 800
16	10	15	17	(Atari 800,(TI 99/4A,TRS Color))
17	9	16	3	((Atari 800,(TI 99/4A,TRS Color)),Vic 20)
18	0	0	19	Ace
19	7	18	20	(Ace,TRS 80-4)
20	6	19	22	((Ace,TRS 80-4),Apple IIe)
21	0	0	2	IBM PC
22	5	20	23	(((Ace,TRS 80-4),Apple IIe),(Kaypro II,Osborne I))
23	3	22	1	((((Ace,TRS 80-4),Apple IIe),(Kaypro II,Osborne I)),(((Atari 800,(TI 99/4A,TRS Color)),Vic 20),Comm64))

ning of the subroutine, and PRINT "pop" before each RETURN statement in that subroutine. This shows how the recursion generates a "stack" of pending business, and how it finishes in a flurry of "pops" that brings it back to the root node.

If you want to experiment more with recursion in BASIC, I'd recommend starting with shorter (and faster) programs. Leal (reference 3) has more discussion of recursion and two short examples.

SOME MACHINE-SPECIFIC NOTES

Since the desired output (see figure 1) involves drawing lines, listing 1 will require some modification to suit the graphics modes of different computers. The only changes should be in lines 930-980 and 1330-1370.

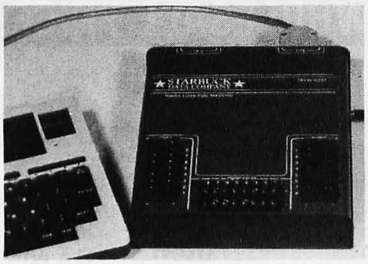
My computer, an NEC PC-8001A, has 160 horizontal by 100 vertical graphics resolution. This is reflected in lines 930 and 940; these plotting functions will produce *x*-coordinates from 30 to 130 and *y*-coordinates from 0 to 90. Change the constants in these lines to suit your machine's resolution and add statements as required to enter the graphics mode. Line 960 clears the screen and line 980 puts the cursor out of the way after the dendrogram has been drawn.

Lines 1330 and 1340 are the line-drawing statements, with the syntax

LINE (*xa,ya*) – (*xb,yb*),PSET

which draws a solid line between the points (*xa,ya*) and (*xb,yb*). Line 1330

(continued)



```
      structured BASIC                comments
      main program
          .
          .
          .
          .
      CP = 1                          set pointer to root node
      GOSUB 2000                      enter subroutine
          .                               .
          .                               .
          .                               .

2000  If B1(CP)>0               begin: if not at the end of a branch,
        THEN                             then
          CP = B1(CP)                      set pointer to left branch node
            GOSUB 2000                       re-enter the subroutine
          CP = A(CP)                       reset the pointer

      IF B2(CP)>0                     if not at the end of a branch,
        THEN                             then
          CP = B2(CP)                      set pointer to right branch node
            GOSUB 2000                       re-enter the subroutine
          CP = A(CP)                       reset the pointer

      {calculate distances,}          {do the task of the}
      {  draw a line, etc. }          {    subroutine    }

      RETURN                          return
```

Figure 3: *The general form of the recursive subroutines.*

draws all the vertical lines in the dendrogram, and line 1340 draws all the horizontal lines. Since the NEC can mix graphics and text on the screen, lines 1360 and 1370 position the cursor and print the names of the nodes at the left of the screen.

For a hard copy of the output, I used a Hewlett-Packard 7225B plotter. It took only a few changes to the lines discussed above so that the appropriate commands were sent to the plotter, which drew the dendrogram in figure 1.

CONCLUSION

I've discussed some of the subjective aspects of cluster analysis in the sections on input and scaling of data. These and other issues should be investigated before using cluster analysis for serious business. It is only one of several techniques used to find patterns in large amounts of data; these other techniques, such as factor analysis and multiple regression, can be used to ensure that cluster analysis is done fairly.

Hartigan (reference 2) is an excellent general reference. He gives many interesting and amusing examples. Hansch and Leo (reference 4) give several examples of cluster analysis in drug design. A very different clustering algorithm is used by Fitch and Margoliash (reference 5), who show how cluster analysis applied to protein sequence data can create a good evolutionary tree.

Finally, about clustering your relatives: if the variables you pick to describe them are age and a series of yes/no variables to indicate whether or not each individual is related by blood to Grandpa Smith or Grandma Jones, the program will produce a fairly good family tree. It's much more fun, though, to use your imagination in variables such as height, weight, hair length, shoe size, smoker/nonsmoker, and beer consumption. You may find that you're much more or less like your relatives than you thought. ■

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(continued from page 136)

rive the other two signals from it. Most family members will accept an external $\phi 0$ clock in place of an internal clock, even if an internal clock is available on that particular version. This clock defines the processor speed. If $\phi 0$ is a 1-MHz signal, the processor is said to be running at 1 MHz. Unlike the 8080 processor family, the 6502 executes a complete bus operation (i.e., the transfer of a full byte) in one clock cycle. On most other processors, a 1-byte transfer requires four or more clock cycles. This difference is the reason that a 6502 is almost always faster than an 8080 or Z80 running at the same clock speed and, conversely, why the Z80 usually uses a faster clock.

The $\phi 1$ and $\phi 2$ clocks are derived from $\phi 0$. For most practical purposes, you can consider $\phi 1$ to be an inverted $\phi 0$ and $\phi 2$ to be equivalent to $\phi 0$. Phase one is rarely used in actual systems but is active when the address and data buses are making transitions in the first half of a bus cycle. Phase two is active during the second half of the bus cycle, when the address bus and data outputs are guaranteed to be stable.

Because the data bus is bidirectional, there must be some way for external logic to determine the moment-by-moment direction of data transfer. The read/write (R/W) line accomplishes this task. If it carries a "1" as defined above, the processor is attempting to read a byte of data from an external device. It could be fetching data or a program instruction from memory or reading data from an input port. If R/W is a "0," the processor has placed data on the bus for delivery to one (or possibly several) external devices. This transfer consists of either a write operation to memory or sending data to an output port. During any given bus cycle, data goes in only one direction. The address bus is used to signal which external device is to participate in the transfer. R/W determines the direction of the transfer, and the data bus carries the data either way. These signals all change state during $\phi 1$ (when $\phi 1$ is active). The address, R/W, and the data-output signals are stable for use by external devices during $\phi 2$, and the processor latches input data at the end of $\phi 2$. Input data must be stable slightly before the end of $\phi 2$ so that values can be accepted by the processor.

Three interrupt inputs are available on the 6502. These signals are sent by an external device, and they force the processor to stop what it is doing and execute a special routine that is logically related to the signal sender. For example, RST is the master reset signal to the processor. Although it may be used at any time, RST is normally utilized only to ensure that the processor starts in a known state after power is applied. For the 6502, this reset forces a minimal number of changes: the program counter is loaded from two specific memory locations containing the address of a "cold-start" routine and the interrupt mask flag is set, prohibiting interrupts via another command called IRQ. All other flags and processor registers are in an unknown state, and the cold-start routine must set any needed conditions before processing starts.

The NMI and IRQ interrupts are more commonly used during normal processing, interrupting the task in progress in such a way that it can be resumed as if nothing had happened in the meantime. NMI is a nonmaskable interrupt, meaning that the processor will acknowledge this signal regardless of what it may be doing at the time. The processor saves sufficient information to permit resuming the current task later and then jumps to a routine that was previously designated as the interrupt handler. IRQ differs from the NMI interrupt in that the processor can choose to ignore it. If the "I" (interrupt mask) flag in the status register is a 0, the processor will acknowledge the interrupt just as it would have for a nonmaskable interrupt, using a routine designated for maskable interrupts. If the I flag is set to 1, however, the processor will ignore the interrupt request. The IRQ interrupt also has a lower priority than the NMI. If both types should be requested

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simultaneously, the processor will execute NMI. With the request of either type of interrupt, the interrupt mask flag is set, disabling further maskable interrupts. It is restored to its previous state after the interrupt-handling routine is done.

The 6502 also provides a few other less commonly used signals. The RDY (ready) signal provides a way to force the processor to wait for slow memory or peripherals. External logic forces this signal to 0 during a read cycle, informing the processor that data will not be available by the end of $\phi2$. This pause in turn causes the processor to execute additional cycles while waiting for the data. External logic can drive the SO (set overflow) line to change the V (overflow) flag in the processor status register to a 1. The SO flag can be used as a low-priority interrupt, particularly during operations that need uninterrupted processor attention during some parts of the operation—with the processor deciding when to recognize the interrupt. It is used primarily in dedicated controller applications. The SYNC signal identifies bus cycles while the processor is fetching the op code (operation code) for the next instruction. It can be used to force single-step execution of a program, as it was on early microcomputers such as the KIM-1.

SYNC signals only the *op-code* fetch and not the *operand* fetch—the address or data to be used by the instruction, stored immediately following the op code in memory. If a SYNC signal were active during the operand fetch as well, it could be used as an extra address bit, placing the program in a memory area completely independent of data.

The final 6502 signal is available on only one of the processors in the family. DBE is a "data bus enable" signal forced to 0 by external logic. DBE makes the processor relinquish control of the data bus by turning off the processor's output buffers and letting another device put data on the bus. This signal only affects the data bus, however. The 6502 always retains control of the address bus and all the control signals, which means that these signals need external buffers in multiprocessor systems.

EXPANDING THE ADDRESS SPACE

The original 6502 address space is limited to 64K-byte locations by the fact that its address bus carries only a 16-bit address. This limitation can be overcome by external "bank-switching" techniques, as can be seen on several of the popular 6502-based computers that are trying to compete with 16-bit systems. Since the 6502 already uses a 40-pin package, it would seem that expanding the address bus would require a larger package for the additional pins that more address bits would need. The next larger standard size, however, is a 64-pin package that is considerably more expensive to produce and in-

tegrate into a system.

Rather than move to a larger, more expensive package, the 65816 provides an additional 8 address bits by using the data bus only during the first half of each cycle. The 65816 puts the 8 high-order address bits on the data bus during the otherwise idle $\phi 1$. The address information can be separated from the data near the processor, providing a full 24-bit address bus for the rest of the system. Alternatively, individual sections can demultiplex the address from the data bus on their own. On the one hand, demultiplexing the address at the processor simplifies the logic for the rest of the system. On the other, allowing individual boards to do their own demultiplexing has several advantages. It lets you add the 65816 and supporting memory to an existing system in such a way that 6502-compatible bus devices will also work with the 65816. Additionally, using a multiplexed address/data bus keeps costs down since it requires less hardware but maintains the same throughput.

BUS CONTROL

Systems with a lot of memory often use dynamic memory devices since they help keep costs down. Because the commonly available dynamic memories use a mulitiplexed address bus, systems with these dynamic memories must include logic to put the right address on the right lines at the right time. Most other processors have clocks that run at a mulitiple of the bus-cycle rate. These clocks ease the problem of designing logic to multiplex the address bus. The 6502 provides only one clock cycle per bus cycle, but certain versions of the 65816 provide an additional clock called phase four ($\phi 4$) to make external logic simpler. This signal runs at the same rate as the $\phi 0$, $\phi 1$, and $\phi 2$ clock signals but is one-quarter cycle out of phase from them. Phase four switches to a 1 one-quarter cycle after the start of $\phi 1$ (at the midpoint of $\phi 1$) and changes back to a 0 at the midpoint of $\phi 2$. On the processor versions that provide the $\phi 4$ signal, all signals except data are valid by the time they reach its rising edge, as shown in figure 1. Since the data bus is used for the high-order address bits at this point, the data is not valid until after the beginning of $\phi 2$. Thus, dynamic memory controllers can pass half of the address to the memory devices at the rising edge of $\phi 4$ and the other half at the rising edge of $\phi 2$. The fact that $\phi 4$ signals valid addresses much sooner than $\phi 2$ permits the use of slower, cheaper memories than could be used for the same system speed if $\phi 4$ were not provided.

The SYNC signal coordinates the bus cycles used by the processor to fetch an op code. On some versions of the 65816, this signal is replaced by two others that provide external devices with a much clearer picture of bus ac-

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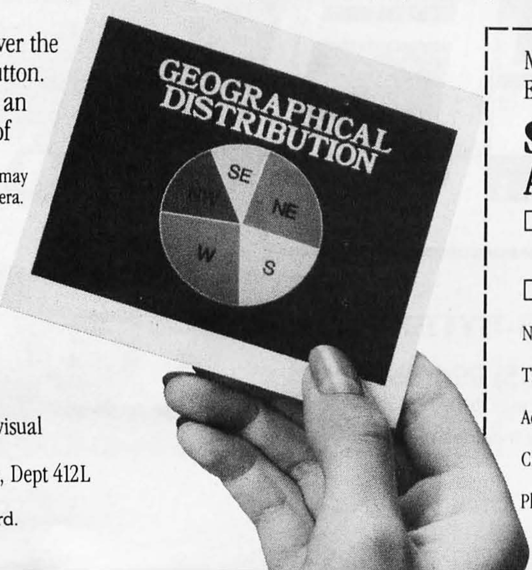

tivity. VPA, "valid program address," includes op codes as well as the associated operands. In this sense, it incorporates the function of SYNC in that it indicates a fetch from program memory. VDA indicates a "valid data address," which would seem at first to be the exact complement of VPA and hence extraneous. During certain cycles, however, the 65816 (as well as the 6502) executes an internal operation and has no need for the external bus. When neither VPA nor VDA are active during $\phi 2$ of a bus cycle, the bus is available for use by other devices. In addition, since the 6502 cannot indicate an idle bus cycle, it must do either a read or a write during every clock cycle. As noted in my article, "The CMOS 6502" (December 1983 BYTE, page 443), this requirement can cause spurious-read problems unless the idle cycle is carefully controlled. For older designs that don't recognize VPA and VDA, the 65816 sets up the bus to refetch the last program byte retrieved during idle bus cycles, thus avoiding the problem of spurious reads. As shown in table 1, VDA and VPA can be combined to synthesize the equivalent of SYNC externally, if required in a system.

The 16-megabyte address space of the 65816 may create the need for systems to include some external memory management to implement virtual memory or error detection. Implementing either of these with the 6502 is difficult because the 6502 continues executing the current instruction even after receiving an interrupt that signals a bus fault. It acknowledges the interrupt only when it starts to fetch the next instruction. In terms of error detection, this process leaves no way to correct the error and resume the process, since internal processor registers would have been altered by the invalid data. Therefore, external logic would have to handle the fault independently, requesting wait cycles until the problem could be corrected. Virtual memory would be even more difficult, since the processor could not be interrupted to move the desired memory into working memory. The 65816 provides an additional interrupt called ABORT which acts like NMI except that it stops the processor in the current cycle. ABORT guarantees that processor registers will not be altered by the instruction being executed at the time. After handling the interrupt, execution resumes by attempting to re-execute the instruction that caused the abort. In combination with VPA and VDA, this signal can be used to provide external caches for both data and program memory.

MULTIPROCESSING

The 6502 is a difficult processor to use in systems that require multiple processors on a common bus. Only one version can even release the data bus for control by another processor, and there is no version that permits external control of the address bus and the control signals. The 65816 family includes versions with either a DBE (data bus enable) or BE (bus enable) input, enabling external devices to force the processor to relinquish the data bus or the data, address, and control buses, respectively. These inputs can be used for direct memory access or a coprocessor on the same bus.

Where two or more processors share access to the same memory and peripheral devices, problems can arise when they attempt access in conflicting ways. In particular, read/modify/write instructions can cause serious trouble. Consider what happens during execution of an instruction to increment a memory location. Since memory devices typically do not include logic for increment operations, the processor must load the data from the memory location, add 1 to it, and store it back in the memory location. Even though the increment appears to the programmer as a single operation, it involves a minimum of two bus cycles: one to read the data and one to return the updated data to memory. If a coprocessor requests and receives use of the bus halfway through this operation, the coprocessor might attempt to store data

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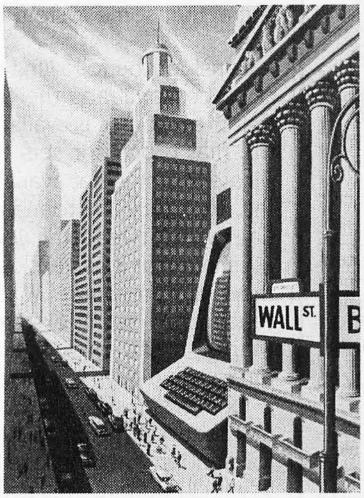

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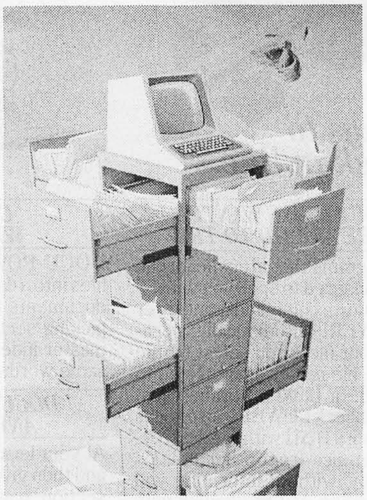

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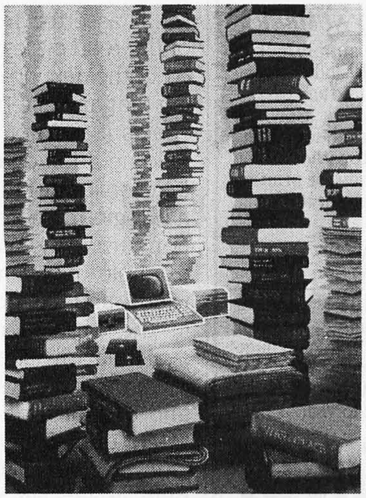

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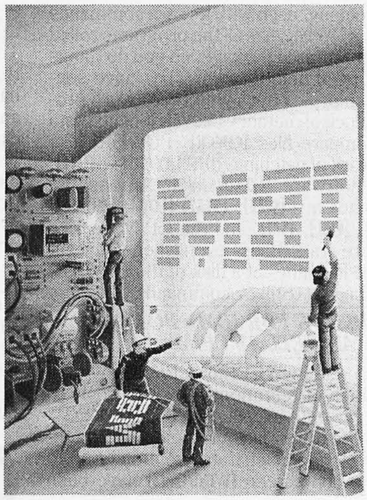

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of its own into the same memory location. When the first processor regains control of the bus, it stores the original (now incremented) value back into the location, erasing the value stored there by the coprocessor. This deletion can be particularly disastrous if that memory location is utilized as a flag to signal that some system resource is in use.

Consider the following scenario. The coprocessor reads the flag indicating that the resource is available just before the first processor sets the flag to indicate that it is not available. But since the first processor found an "available" flag when it read the location, it too assumes that it has exclusive control of the shared resource. While this occurrence may seem extremely unlikely, Murphy's Law prevails to an extraordinary degree in such systems.

To prevent such an occurrence, the members of the 65816 family intended for multiprocessing have an ML (memory lock) output. This active-low signal is asserted during read/modify/write instructions, indicating to external logic that the bus cannot be reassigned to another master during this operation. ML is asserted from the middle of $\phi 1$ of the read cycle through the middle of $\phi 1$ of the next op-code fetch, guaranteeing that any external processor that respects it will not interfere.

Some additional new signals on certain versions of the 65816 permit external logic to more closely monitor actions inside the processor. On some, for example, the E (emulation), M (memory width), and X (index register width) flags in the processor status register are available on external pins for use in memory and system management. VDA and VPA provide more complete control of bus activity as mentioned above. One additional signal, VP, or "vector pull," greatly simplifies implementation of a vectored interrupt system by signaling when the processor is fetching an interrupt, abort, or reset vector.

The 65816 manages to retain a hardware interface that is similar to the 6502, promising many applications in upgrading present systems. With additional versions providing new signals, it can expand into large systems that were previously impractical, using large system features such as virtual memory and multiprocessing. ■

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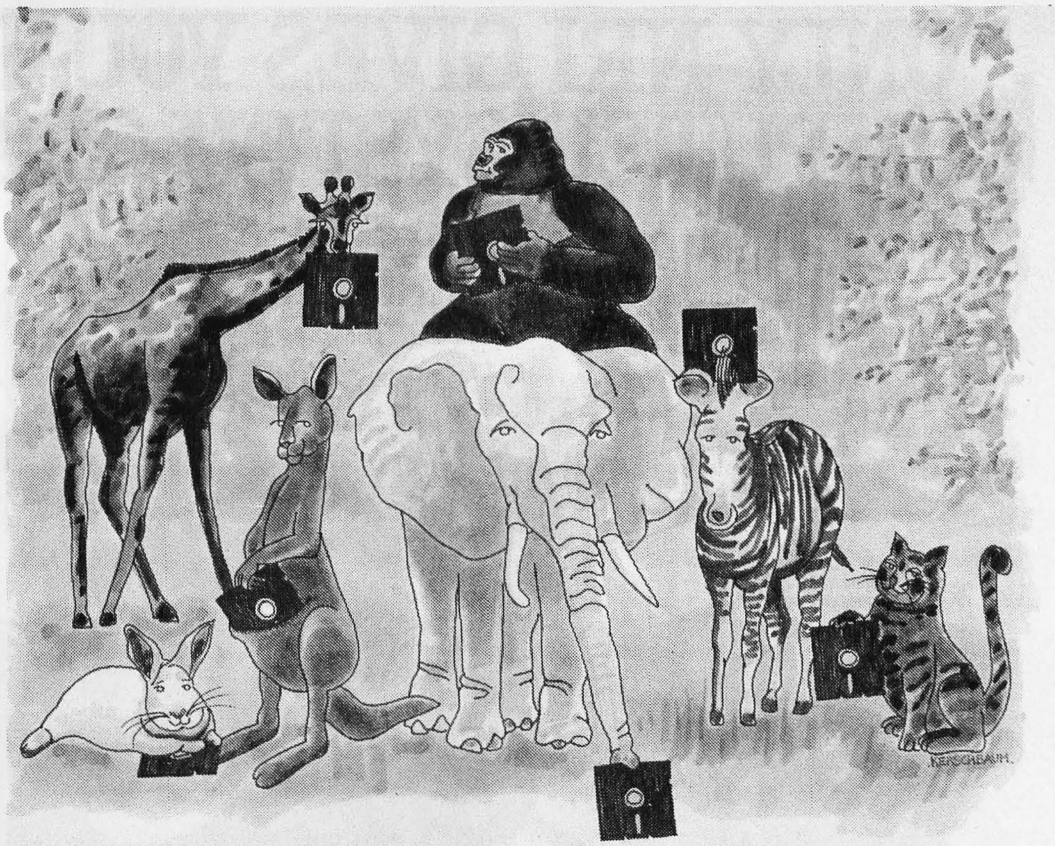

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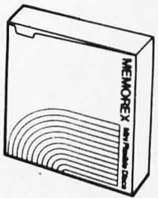

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———	———	3090-P	2.39	———	———	———	———	———	———	800605-P	2.69
———	———	3102-P	2.89	82701-P	2.89	F2D-S-P	2.89	FD2D-P	2.89	800803-P	3.14
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———	———	3104-P	2.89	82708-P	2.89	F2D-S1024-P	2.89	FD2D-1024-P	2.89	800839-P	3.14
———	———	———	———	———	———	———	———	———	———	———	———
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———	———	———	———	———	———	———	———	———	———	———	———
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(continued from page 147)

compatibility with operating systems, and so on.

A floppy disk is made up of as many as 80 tracks, divided into *sectors*. Sectors isolate blocks of data and help you manage data more effectively. All aspects of a sector work together. If a single data bit is changed, then all the data in the sector must be rewritten. Without sectors, a 1-bit change would mean that every other piece of information on the whole track would have to be rewritten.

A *cell* is a division of a sector. It is the space wherein 1 data bit exists. Sector size and shape, as well as the number of bit cells (bit density), vary significantly from one format to another. They all depend on the chosen layout and encoding scheme. Most disks are divided into between 8 and 16 sectors, although division of up to 51 has been used.

HARD SECTORS VS. SOFT SECTORS

Hard and soft formatting are the two techniques used to define sectors. In a hard format, holes are punched into the disk at the beginning of each new sector. In a soft format, a hole is punched only at the beginning of each track. North Star Computers Inc., one of the first companies to manufacture personal computers, used hard-sector formats. Back then, hard sectoring was more economical than soft sectoring because it could be used with a less expensive controller. Technology has since changed. It is now possible to build an integrated controller on an IC (integrated circuit) chip, and a hard-sector format, for most applications, no longer has a price advantage. IBM, Apple, Commodore, and most other computer makers use soft-sectored formats.

Figure 1 illustrates a typical soft-sectored format. Each sector is divided into an identification (ID) field and a data field. Combined, the fields contain the following subfields: two gaps, two synchronization subfields, two marks, either an identification subfield or a data subfield, and one subfield of error-detection codes. The data subfield within the data field is the most important part of the sector. It contains the user's data. Typically, it holds from 128 to 1024 bytes of data. The ID subfield contains only permanent address and housekeeping data and is typically about 4 bytes long.

A *gap* is the space between fields. It serves as a buffer zone separating any two fields that might be rewritten separately. The size of a gap can vary. If the size of a gap is reduced, the number of sectors can usually be increased. There is a trade-off between disk-drive speed variation and gap size. The controller takes a fixed amount of time to rewrite a data

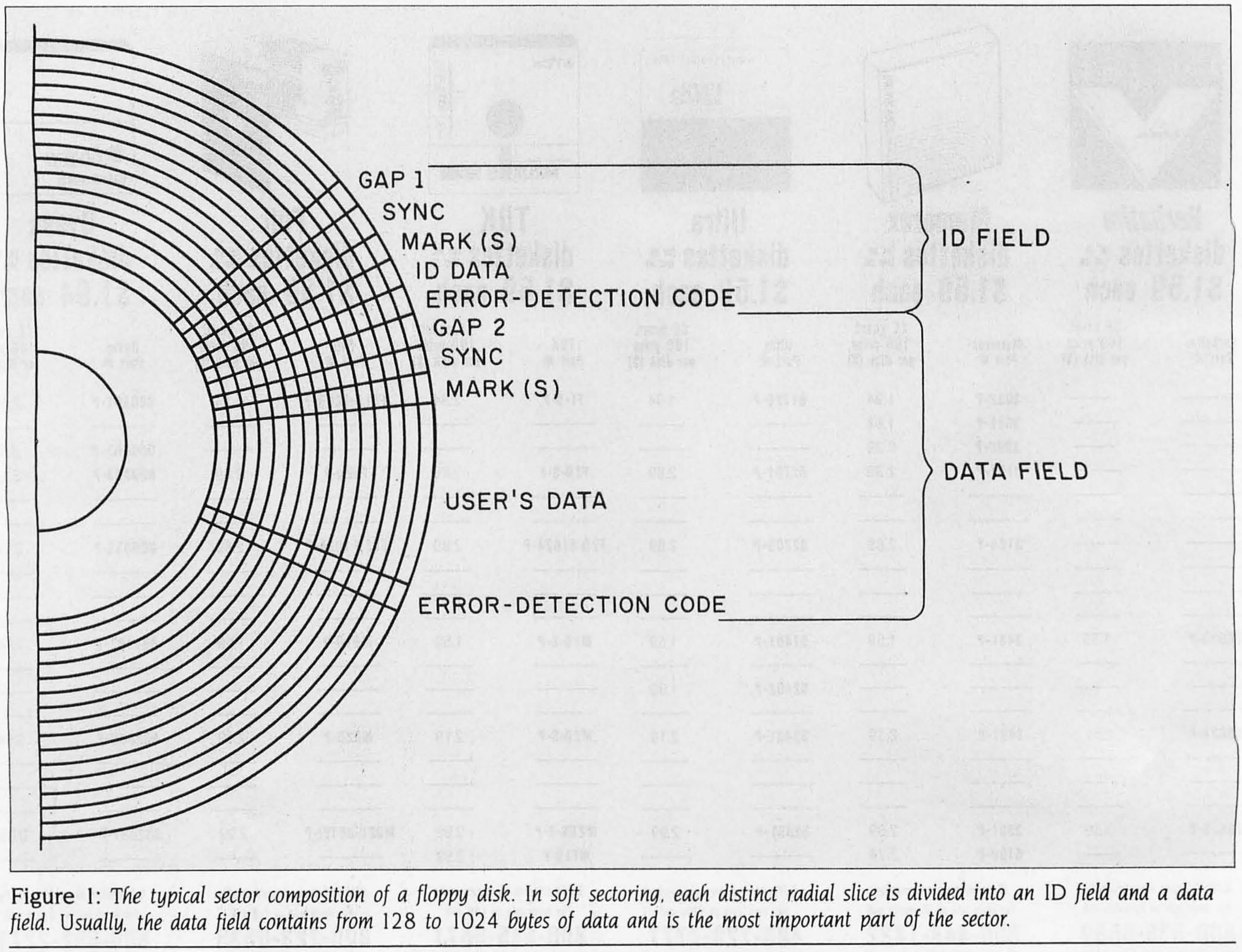

Figure 1: *The typical sector composition of a floppy disk. In soft sectoring, each distinct radial slice is divided into an ID field and a data field. Usually, the data field contains from 128 to 1024 bytes of data and is the most important part of the sector.*

field. If the drive turns more rapidly during rewrite than during original formatting, the controller could overwrite the next ID field. The smaller the gap, the greater the likelihood of an overwrite error.

The sync field alerts the computer to the kind of information that is coming. It is like a signpost that says, "Road narrows in 20 feet." The sync field enables the controller to adjust to the precise speed of the disk and to differentiate between data and clock transitions (discussed later). There are different kinds of sync fields, each designed for a particular data-reading technique. As a general rule, however, the greater the sync field's capacity to adjust for speed and offer increased reliability, the greater its length and, hence, the less room there is for storing data.

A *mark* is used to indicate how data is organized into a byte, i.e., 8 bits. It indicates where a byte begins and confirms that a sync field is in fact what it seems and not simply a data byte that resembles a sync field. A mark usually has a unique pattern so that the computer can distinguish it from everything else.

The identification subfield of the identification field contains addresses and other housekeeping information. It always carries the track and sector numbers. It might also carry information such as the size of the sector and the side of the disk. In soft-sectored formats, the ID field is formatted once and never rewritten. In many hard-sectored formats, however, the entire ID subfield is included in the data subfield because there is no separate ID field. This way, every time the user writes new data, the ID information must be rewritten.

The data subfield of the data field contains the actual information that is stored on the disk. This subfield is where the computer user can enter programs, text, or any other information. The amount of space available for the data field is determined by how much space is left after all the other format components have taken their share of the disk.

It is easy to make mistakes reading from magnetic media. A read error can occur in either the ID field or the data fields. The computer checks for blunders with an error-detection code (EDC) usually written into each field. It verifies the accuracy of the read operation and reports problems. There are many different ways to do this, but the two main methods of error detection are checksumming and cyclic redundancy checking.

With checksums, an entire block of data is added up and the resulting sum is written at the end of the block as a check byte. That check byte is compared with a separate check byte that was recomputed and generated during the read operation. If they are different, there is an error in the block. Additional checksum bytes can be used to increase the accuracy of the error detection.

A cyclic redundancy check (CRC) is an algorithmic technique for verifying that information within a block is correct. The CRC word is usually at the end of every field and indicates the integrity of the preceding data. Special circuitry verifies the CRC by first recomputing it and then comparing that result to the CRC value that is read from the disk. **[Editor's Note:** *For more information on error-detection schemes, see "The Theory of Disk-Error Correction" on page* 145.**]**

(continued)

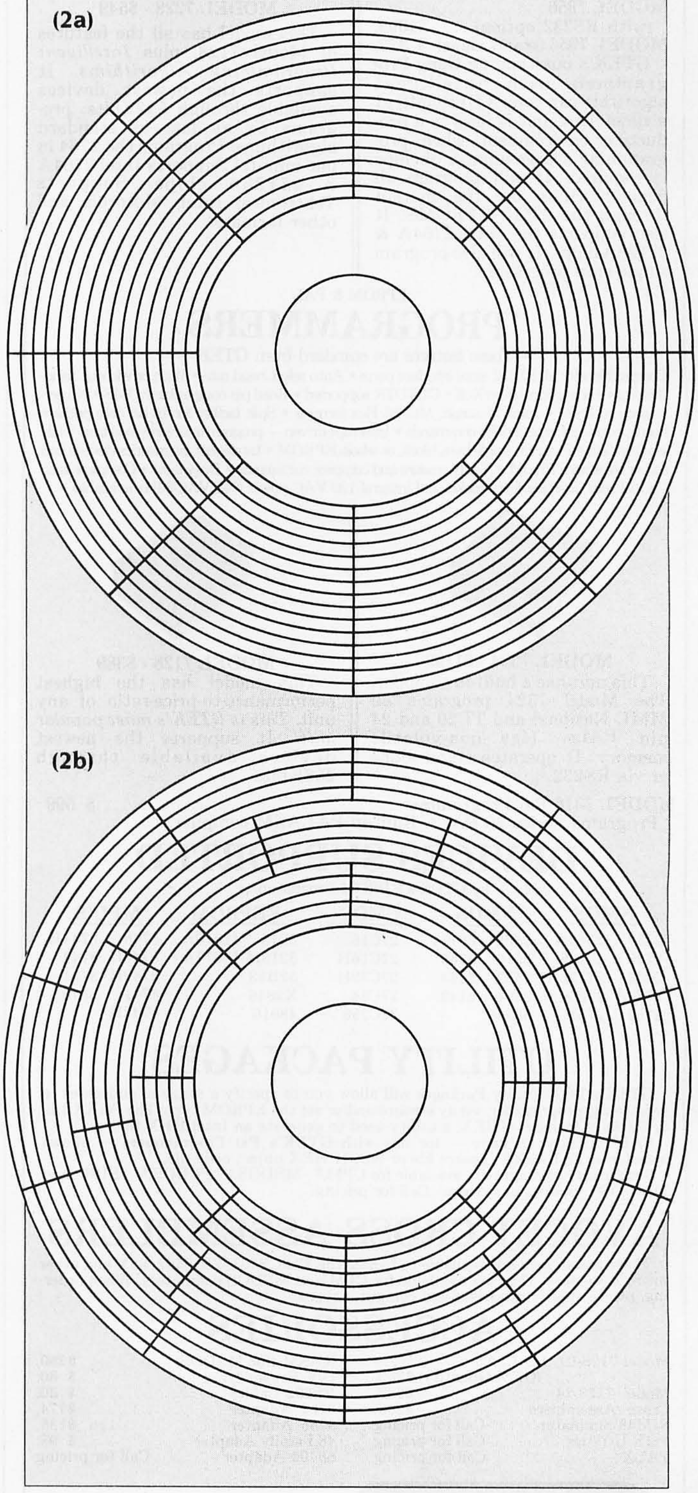

Figure 2: A *typical eight-sector layout with radius sectors* (*a*). *Sector layout traditionally focused on the pie cut. Newer methods involving fixed-bit-cell sectors* (*b*) *enable a disk to hold up to* 40 *percent more data.*

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To put digital information on any storage medium, the north/south magnetization on its coated track must be changed. This is called a transition *and is done by an electromagnetic head.*

THE DREADED BDOS ERROR

An error that terrorizes CP/M users is the BDOS (basic disk operating system) error. It is a flag that can indicate several possible system errors. Some of the candidates relate to disk formats (usually EDC errors), others relate to user errors. The most feared EDC possibility is one indicating that the sector cannot be read correctly. It means that the data *field* contains the error and that the data itself usually is unrecoverable. There are other possibilities: a sector's ID field cannot be read correctly or cannot be found at all, or the expected ID field track or sector number cannot be found, indicating a hardware failure or, in rare cases, a problem in the operating system or the application program.

Most BDOS errors occur during a read operation. If one occurs during a write operation, it is probably because a read error resulted from the disk controller having to read the desired ID field first and then write the user's data in the data field, the selected disk drive is not ready, or the user executed a read-after-write verification procedure and the read part of the procedure failed.

WRITING DATA

To put digital information on any storage medium, the north/south magnetization on its coated track must be changed. This change is called a *transition* and is instituted by an electromagnetic head. On floppy disks, the electromagnetic head detects the transitions (reads the disk) by recognizing a small voltage surge when one passes by.

Computers work, of course, with 1s and 0s. Generally, within a bit cell, a 1 is represented by a transition and a 0 by its lack. This is fine as long as there are few consecutive 0s. A string of naughts causes the detector to lose track of a cell's beginning, particularly if the disk's rotational speed varies. Several encoding schemes attempt to deal with the reliability problem. Most of them use an extra transition, called a *clock*, to mark the start of a cell. These clocks define the boundaries of a cell and prevent the detector from getting lost. Clocks ensure greater reliability, but not without a price. They take up valuable disk space.

The primary goal of any formatting scheme is balance between storage capacity and reliability. The two main factors that affect this goal are encoding types and sector layout.

ENCODING TYPES

FM (frequency modulation) is the oldest and most reliable encoding type. It uses a clock between every data cell and

a sync field consisting only of clocks. Using an all-clock sync field creates a distinctive section on the track, but if there happen to be all 0s in the data, the data field could look just like the sync field. So a mark is used to confirm the sync field. In FM, a mark is made by violating clock rules. Unlike the rest of the data, its pattern contains some missing clocks.

(continued)

Table 1: *In group coded recording* (GCR), *a table translates the input combinations to or from the output combinations.*

Input Combination from/to Computer	Output Combination to/from Disk
0000	01010
0001	01011
0010	01001
0011	01111
0100	10110
0101	10101
0110	11101
0111	10111
1000	11001
1001	10011
1010	11110
1011	01101
1100	01110
1101	11011
1110	11010
1111	10010

Table 2: *The basic difficulty with squeezing transitions closer together is bit shifting, which causes read-back errors.*

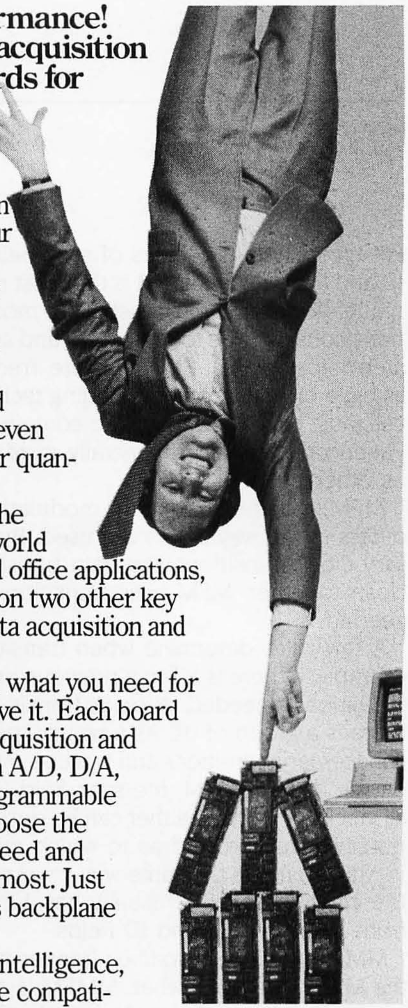
```
Written transitions   . .1———1—1————1—1—1. .
Read-back transitions . .1————1—1————1—1—1. .
```

Table 3: *A technique called precompensation compensates for bit shifting by taking advantage of the partial predictability of the read errors it produces. Locations of probable errors can be known in advance and compensated for during writing.*

```
Ideal bit positions  . .1———1—1————1—1—1. .
Precompensated write . .1————1-1—————1-1—1. .
Read after bit shift . .1———1—1————1—1—1. .
Transition number       1    2  3     4  5   6
```

Table 4: *A pattern table is the mechanism by which bit shifting is predicted. It takes into account the amount of spacing between transitions and assigns the proper direction and magnitude to each compensating shift.*

Transition Number	Magnitude	Direction
1	0	
2	150	late
3	150	early
4	150	late
5	0	



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FM typically puts 6 bytes of sync field in front of both the ID and the data fields. FM is the most reliable encoding technique; however, it also wastes the most disk space because transitions can't be too crowded, and as many as half of them aren't storing data. FM, therefore, frequently requires twice as big a bit cell as other encoding techniques because every cell must have the capacity to contain both clocks and data. FM-encoded disks can, generally, store only half as much data as other types.

MFM (modified frequency modulation) resembles FM but differs in the way clocks are used. By eliminating unnecessary clock transitions, the data transitions can be twice as close together. MFM uses transitions only when they are needed.

A few rules determine when transitions are needed. For example, if there is a 1 in a previous or current cell, no clock transition is needed. A clock transition is used only when there is a group of 0s. As a result, space is not taken up by unnecessary transitions and twice as much data can be stored on the disk. In MFM, the sync field is composed of either all clocks or all data; either can be designated. The host computer is preinstructed as to which method to use. A mark in MFM is made the same way it's made in FM: by violating the clock rules. MFM usually has 12 bytes of sync field in front of both data and ID fields.

MMFM (modified modified frequency modulation) changes the MFM rules somewhat. MMFM is similar to MFM except for the fact that it places clocks only after every other 0. This technique offers some slight theoretical improvements over MFM, but very few people use it.

GCR (group coded recording) eliminates clocks entirely. GCR is a self-clocking system. Instead of clocks, a change in bit grouping is used to eliminate consecutive 0s. Generally, 4 to 8 bits of input information are organized into a longer bit-length output combination. A table translates the input combinations to or from the output combinations. An example is shown in table 1.

The GCR scheme avoids the problem of too many 0s because the transition table insures that there are never more than two consecutive ciphers, even when two 5-bit patterns are joined. Since no space is wasted on clock transitions, there is more room for data. GCR-encoded disks can store between two and two-and-one-half times as much data as FM types. Many different combination tables can be used. Commodore uses a 4- to 5-bit combination table *similar* to that shown in table 1. Apple Computer uses both a 5- to 8-bit and a 6- to 8-bit table, depending upon the operating system revision level. Sync fields are used to establish the size of a bit cell, as in FM or MFM, but are not necessary to differentiate between clocks and data. A mark is used in GCR to recognize the start of the byte organization. It is usually a unique pattern that is reserved within the pattern table and is used exclusively as the identifier.

SECTOR LAYOUT

Sector layout affects as profoundly as encoding the amount of data that can be stored on a disk. Sector layout has traditionally focused on the "pie cut," or radius sector layout, method of dividing a disk (see figure 2). The ideal number of sectors in this method is a topic of much discussion. With

Table 5: *Formatting families fall into natural family groupings, dictated by the controller, which also determines the disk's data capacity, the error-detection code, the particular mark or unique identifier, and the pattern of the synchronization field.*

Format Family	Controller	Encoding Method	Error-Detection Code	Sync Field	Mark
IBM					
IBM FM	Intel/NEC	FM	CRC-CCITT	6 bytes 0s	data FE or FB, clock C7
IBM MFM	WD 1771, 179x, WD 2903	MFM	CRC-CCITT	12 bytes 0s	data A1, clock 0A
Kaypro		MFM	CRC-CCITT	12 bytes 0s	
Morrow		MFM		CRC-CCITT	12 bytes 0s
Eagle		MFM	CRC-CCITT	12 bytes 0s	
Apple					
Apple II	proprietary	GCR	checksum	special	D5 AA
Macintosh					
Franklin	proprietary	GCR	checksum	modified through software	D5 AA
Milliken	proprietary	GCR	checksum		D5 AA
Commodore					
Commodore	proprietary	GCR	even parity	1s	07 or 08
Victor	proprietary	GCR	checksum (2-byte)	1s	07 or 08
Others					
(Hard-sector and other formats)	proprietary	FM, MF, MMFM	many	0s or 1s	varied
			CRC-16	AA,1010	
			CRC-CCITT	varies according to initialization and bytes included	
Lanier (AES)			parity		
Burroughs			checksum		
DEC		FM/MFM mixed	error-correction code		
Datapoint		FM/MFM mixed	CRC-CCITT	0s	FD, F9

Although precompensation increases transition crowding and consequently is partially self-defeating, it is frequently used to improve reliability.

more sectors, the data is more manageable, but at the cost of capacity. Each sector needs space for gaps, sync fields, marks, and error-detection codes, which costs vital data space. In addition, there is the secondary problem of wasted space on the outer tracks of each disk. (While there is much more room to record data on outer tracks, controllers can handle only a constant number of bits, and the inner, smaller tracks usually determine the bit-cell capacity of all tracks.) This led to a new sector layout based on a fixed-size bit cell instead of the traditional fixed-radius sectors.

With the fixed-bit-cell sector method, sectors are added on the outer tracks to maintain an approximate bit-cell density over the entire disk. As the track size increases from the center of the disk, the outside tracks can contain more sectors than those on the inside (see figure 2b). A 5¼-inch disk with this type of layout can record up to 40 percent more data than one with the fixed-radius format. The fixed-bit-cell method, though only a few years old, is now used by Commodore, Victor, and by Apple on its Macintosh.

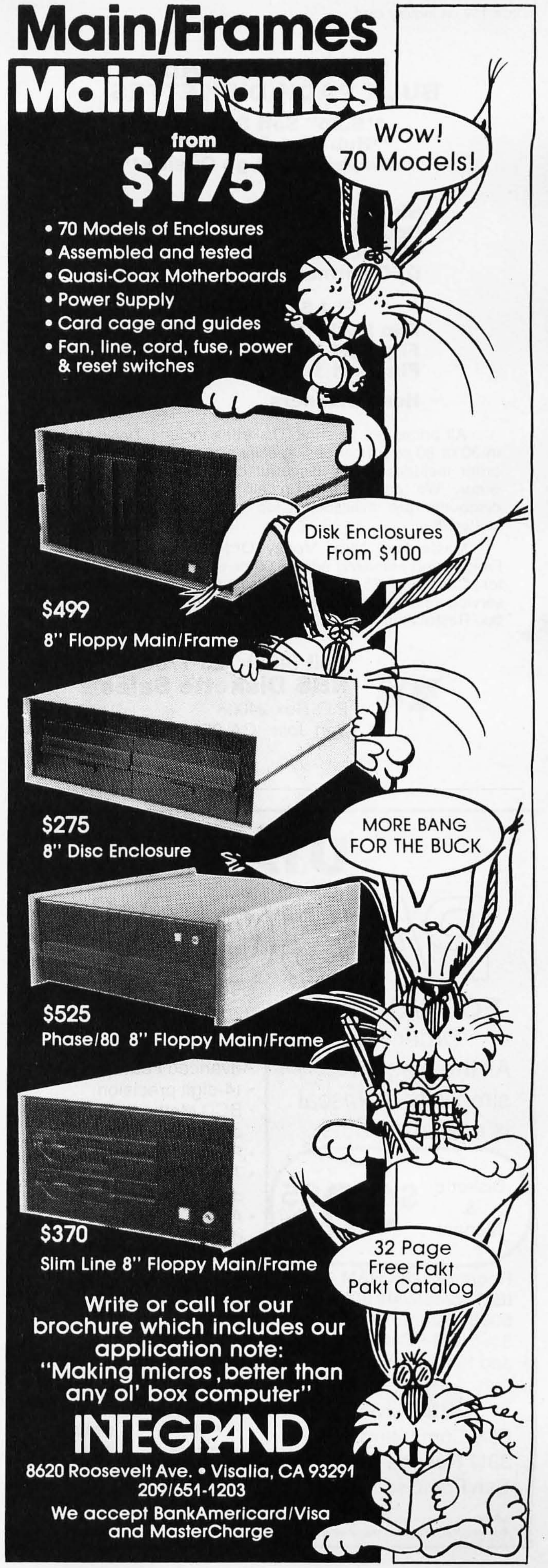
PRECOMPENSATION

More efficient clocking and sector layout has increased the amount of data that can be stored on a disk. Another way of increasing data storage is to squeeze the transitions even closer together. As transitions are squeezed, read-back degradations limit the amount of squeezing that can be tolerated. Bit shifting or, more accurately, transition shifting occurs. Bit shifting during the read operation is the apparent shift of the transition's location away from its written position due to crowding. As transitions are squeezed closer together, the percentage of shift increases and the probability of inaccurate transition detection occurs. An example of bit shifting is shown in table 2.

Fortunately, bit shifting is partially predictable, and it is possible to compensate for some of the bit shift. By using precompensation, either the transition density or the read reliability can be increased. An example of precompensation is provided in table 3. Precompensation increases the transition crowding and, consequently, is partially self-defeating. Nevertheless, it is frequently used to improve reliability.

The amount of bit shift depends on the spacing between transitions. Different bit shifts occur for different pattern variations. When a pattern table is developed, each pattern is usually assigned a shift magnitude and direction. Using the example given in table 3, the pattern might look like that rep-

(continued)



The controller dictates the number of bytes on a disk, which EDC can be used, the unique identifier used, and the pattern of the sync field.

resented in table 4.

In practice, tables are usually developed with a single magnitude; e.g., a precompensation of only 150 ns (nanoseconds) or 0. However, some machines have been developed that use as many as three different magnitudes; e.g., some patterns with 50 ns, others with 150 ns, and yet others with 250 ns.

FAMILIES OF FORMATS

Technological developments have solved format problems and refined the formats themselves. Formatting characteristics fall into natural family groups (see table 5). The controller dictates the number of bytes on a disk, which EDC can be used, the particular mark or unique identifier used, and the pattern of the synchronization field. The controller dictates most of the format characteristics and therefore defines the major families.

Apple's controller is mostly a software program. Commodore's approach is similar to Apple's, but the formatting is controlled by firmware. The IBM format controller is in hardware, with some variation permitted by software. Tandy and Texas Instruments are in the IBM family. Victor is in the Commodore family because it uses many of the Commodore concepts.

A fourth family consists of hard-sectored formats and those that just don't fit in any of the other categories. This fourth family is used by North Star, some Hewlett-Packard equipment, Lanier, and Phillips.

IBM

IBM started with FM in the earliest floppy disks but chose MFM for its Personal Computer (PC). FM was, initially, the most widely used approach. The IBM family uses Intel/NEC 765 or Western Digital 179X and 2903 controllers. These controllers work only with FM and MFM. The controllers are designed to accommodate sector sizes of 128 to 1024 bytes. When using FM encoding, the IBM family uses FE and FB marks with C7 clocks. With MFM encoding, this group uses A1 marks with OA clocks.

IBM adopted an error-detection code called CRC CCITT, a method more complicated than a checksum technique. The controller is actually designed to be able to handle this special EDC and cannot execute, for example, a checksum. The IBM family of formats uses the radius sector layout recording method, so the bit-cell densities are greater closer to the hub hole. As a result, the amount of desired precompensation is greater on the inside tracks. Most IBM PCs, however, do not vary the precompensation from track to track.

APPLE

Apple Computer chose GCR technology when designing its system. Apple's priority appears to have been economy. By using GCR it could put almost all controller functions in software, which doesn't have recurring costs. GCR also offers pretty good density, about the equivalent of MFM, and it uses hardware that's less complicated. Apple designs and manufactures its own controllers, which are dedicated to the GCR encoding scheme. They are designed to accommodate sector sizes of 256 bytes and utilize a checksum EDC. The Apple family uses D5 and AA marks. The Apple format family, with the exception of the Macintosh, uses the radius sector layout recording method. Apple adopted the fixed-bit-cell method when it developed the Macintosh. As a result, the Macintosh has more relative data-storage capacity.

COMMODORE

Commodore also chose the GCR method, but apparently not for economic reasons. It seems Commodore was most interested in squeezing more data onto the disk. Commodore uses a slightly different GCR conversion than Apple. By using a more expensive controller, Commodore sacrificed the economy Apple achieved. Both Commodore and Victor manufacture their own controllers, but the units are similar enough to be clearly related. They both work with sector sizes of 256 to 512 bytes and a checksum EDC. The Commodore family uses 07- and 08-type marks. Fixed-bit-cell sector families, such as Commodore, do not need to vary the precompensation from track to track.

Within the IBM PC family, there are three fundamentally different formats with 8, 9, and 10 sectors, respectively. While an IBM PC can read its own 8-, 9-, and 10-sector formats, it cannot read those of other families such as Apple and Commodore.

STANDARDIZATION

The floppy disk will probably be around for some time since nothing else can now challenge its cost-effectiveness. A floppy disk can store up to 1 megabyte for about $5. Winchester drives can store more than a floppy disk of comparable size, but the price is much higher. Winchesters are coming down in price but will always be more expensive. Price is also a parameter in terms of the controller that works with the floppy disk. Furthermore, the installed base of computers that use floppy disks is large, and most owners would be reluctant to change to a new type of disk if the cost is a new computer.

One of the areas currently being explored is data and format conversion. There is a great need for this technology but, as yet, it remains on the wish list in most cases. The lack of formatting standards is neither a minor nor a temporary problem. However, it is diminishing as IBM, Apple, and Commodore become dominant. IBM's presence has driven the industry toward IBM's format standards, but not all the way. The fact that Apple used a different format scheme in the Macintosh indicates that standardization is not on the horizon. Nobody seems to have the power or desire to compel standardization, and many companies face more pressing problems. Format standardization will have to wait. ■

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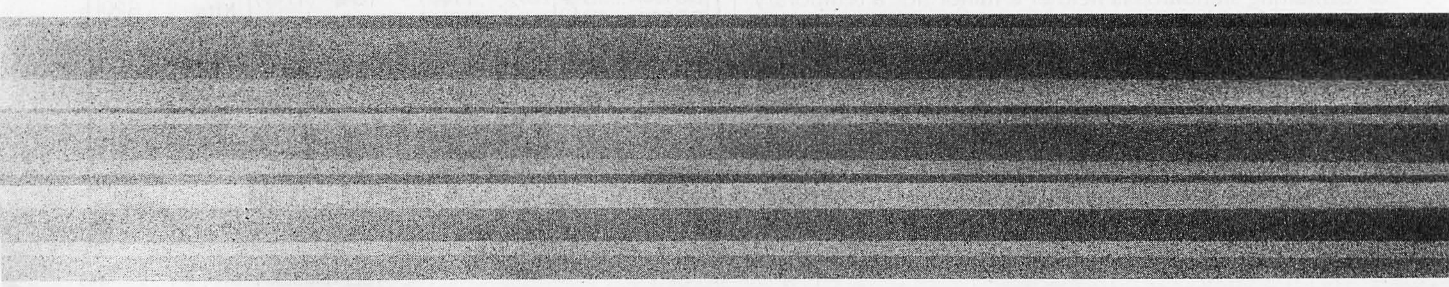

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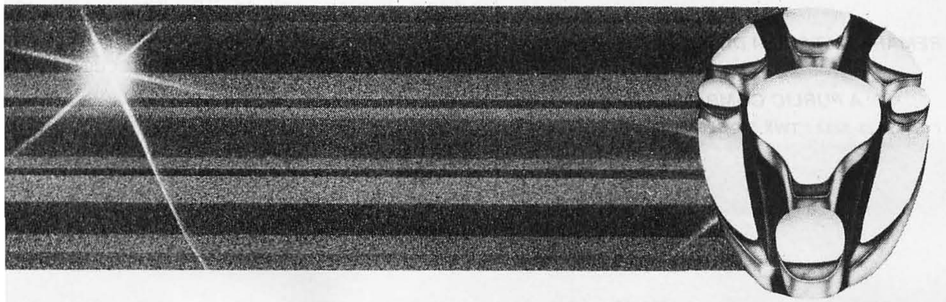

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(continued from page 151)

in one working day.

2. Quality—A team that designs, tests, codes, and *reviews* its own work is more likely to catch bugs early and test code thoroughly.

Of course, there are major disadvantages to teamwork. Two people working together are not necessarily twice as fast as someone working alone because of the extra organization and discipline needed. A group of two or three is just about the right size for most microcomputer projects; more than three can spend too much time organizing and arguing. If you cannot find anyone who wants to work closely with you, at least try to find a friend who is willing to look over your design and test the final product.

When you have an estimate of the size and difficulty of the project, it is a good time to ask yourself these questions: Do you have the time and resources to complete the project? Can you modify (or make do with) an existing software package? If you have doubts, develop a usable prototype first, before committing yourself to a full-scale project.

Before you start the project you should also consider what resources (hardware and software) you will need. It is vital to choose a good *programming environment*. If you do not have the right tools, the project will take far longer to develop and may be a flop.

SOFTWARE TOOLS FOR LARGE PROJECTS

Naturally, your choice of tools depends on your project, but it is better to be cautious and get all the tools you can.

You should have a reliable operating system that supports a good set of utilities and commands for systems programming (such as allowing you to create command abbreviations and execute files of commonly used sequences of commands). UNIX, or one of its look-alikes, is a good choice. For example, you can edit a program while waiting for a listing to be printed because UNIX supports concurrent user tasks. (On the other hand, if that's all you need multitasking for, perhaps it would be better to buy a good printer buffer.)

Simple operating systems, like CP/M, can hinder your productivity. More recent operating systems, like Concurrent CP/M, are evolving toward UNIX as microcomputer users and hardware become more sophisticated.

Another useful tool is a good screen-oriented editor that supports global searches and changes. Preferably, it should be able to handle large files. If you use a "virtual" editor—one that buffers the text on disk during edits—you *must* have reliable disk drives. Virtual editors (which include WordStar and WordMaster) have been known to die right in the middle of the last correction in a 2000-line program.

You also need a production compiler for a high-level language that allows you to compile large programs in separate pieces. This *separate compilation* feature

means that you are not faced with a long, slow compilation each time you make a minor change in a large program. Know your compiler. If you're familiar with one brand and you plan on its features being available on a new computer, you may be disappointed. For example, we are familiar with several production CP/M Pascal compilers, and no two of them accept exactly the same language. This is a problem with other languages as well.

There are several things to look for in a production compiler. If the language in question has a test suite, can the compiler handle everything in it? Read the fine print carefully: some compilers will fail an entire list of tests just because a particular feature is missing. How long has the compiler been available? If it's new, worry. New compilers often contain large, hungry bugs. How well supported is the compiler? Often, the smaller the company, the better the quality of support. On the other hand, larger companies tend to stay in business longer and have a larger base of public-domain tools available for their products. If you're using a compiler you've been familiar with for a long time, make sure you know all of its features. If you're moving from one machine to another, find out just how similar they are. Run some small test programs, ask another programmer, and read the literature for reports on new compilers.

Some compilers for microcomputers are not designed to handle programs more than several hundred lines long. They may die mysteriously on larger programs as they run out of space for names, tables, or code. If a compiler won't let you break the program into separate pieces, you probably will have to either scrap the compiler or stick to smaller projects.

Some languages, such as BASIC and Assembler, are not suited to large projects at all. If you are going to write hundreds of lines of code, use a high-level language so that you can implement algorithms and data structures without worrying about how to squeeze data into fewer words of memory.

With high-level languages, programs are more readable and errors can be caught before you even start testing. Familiar languages such as Pascal and C are good choices, especially if you have access to a "good" compiler (i.e., a fast compiler that generates efficient code and meaningful error messages). You should always try to use a portable language or language subset in case you later decide to move the project to a new environment.

There are many dialects of Pascal, all with different conventions for providing disk I/O (input/output). If your code is full of disk I/O calls and subtle assumptions about the way disk I/O works, transporting that code will be a nightmare. The best approach is to avoid using nonstandard features when possible, and isolate procedures using nonstandard features so that they are easily identifiable and replaceable.

Another useful tool is a word processor for documentation. It is a good idea to keep all documentation on line so that you can continually update it. If you rely on scraps of illegible handwritten notes to track design changes and testing, you will find the software much harder to maintain and debug.

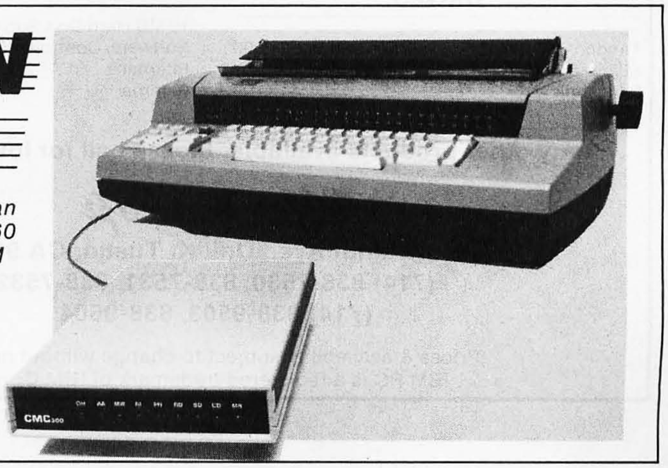
To develop large programs you also need a good archival file system.

To develop large programs you also need a good archival file system. Most large computer systems have schemes such as daily backups to enable you to recover from "crashes" and restore earlier versions of your software. It is up to you to make sure that your floppy disks remain readable—you don't want to have to retype 5000 lines of code from old listings. Make sure you have lots of spare floppy disks and a labeled rack or binder to hold them. (Some people even keep copies in different buildings just in case their houses burn down.)

Backups are useful for much more than just recovering from crashes. During testing, fixing one bug may mysteriously create another one. If you have been making a series of fixes, it is necessary to determine which fix caused the new bug. If you do not have copies of all the versions prior to each major fix, it can be difficult to find the cause of the new bug.

Some operating systems, such as UNIX, provide special tools to help you keep track of old versions of your software and easily remake new versions. Keeping track of versions is much easier

(continued)



if you always place comments in your source code that explain the history of the code, and if you keep dated and time-stamped listings of old versions for security. A typical list of revisions might look like:

4.51 10 Oct 83 Fixed character I/O hangup bug in GET_INPUT module.

4.51a 11 Oct 83 Really fixed 4.51 bug. It was a problem in CHAR_ACCEPT procedure.

DEBUGGING TOOLS

Some compilers and operating systems provide tools to let you locate bugs easily. Nothing is more frustrating than a program that mysteriously hangs or crashes, leaving no clue to where it was before it died. Many microcomputer operating systems offer such helpful hints as "STACK OVERFLOW" or "ILLEGAL INSTRUCTION."

The ideal tool in such circumstances is a *symbolic debugger*, which allows you to step through your program an instruction at a time, set breakpoints at the start of procedures, and examine the values of variables while your program is executing. Of course, you can do the same tracing by hand by inserting print statements everywhere, but a symbolic debugger can make life much easier.

Check to see if debugging tools are available for your compiler, preferably before you buy it.

Machine-code debuggers that let you step through machine instructions and peek at memory are less useful than symbolic debuggers. To use them you have to learn irrelevant details like how the compiler allocates memory addresses for variables.

Another useful debugging aid is the ability to do run-time checks, such as array-bounds checking in Pascal. It is also a good idea to design similar consistency checks into your software to simplify debugging and testing later. Never turn off run-time checks just because your program is now "working." In a complex program, bugs may show up later.

Interpreters and operating systems that "dump," or let you examine the state of a program when it crashes, are also useful. However, don't rely on these tools too much. It's often better to throw out a module than patch the patches' patches.

Naturally, it also is important to have adequate hardware resources for the project before you get started. Developing large software projects is much more enjoyable if you have a good fast printer, a comfortable keyboard, a screen that is not hard on the eyes, and a hard disk or RAM (random-access read/write memory) disk to speed file handling. Nothing is more pointless than spending weeks trying to squeeze your software to fit into 32K bytes of RAM if more memory can be added to your system. Attempting to tailor your software to fit arbitrary machine constraints is like push-starting your car to avoid buying a new battery.

If you are short on cash, though, buying good software tools should have priority over fancy hardware. Crisp, clean listings will not help if you have to do battle with an incomplete, inefficient, or poorly documented compiler.

SPECIFICATION—THE STRUCTURE OF THE SOFTWARE

The specification phase of software development consists of taking the description of what the software should do and splitting it into functions that are to be performed by separate components, or *modules*. Modules may be implemented as subroutines, or they may consist of a collection of data and subroutines (such as a UCSD Pascal unit). This process of breaking down the software into smaller components is often called *top-down* design. Eventually you end up with a hierarchy of modules that can be illustrated by a structure diagram.

For example, suppose you were going to develop your own version of a popular arcade game. During the requirements-analysis stage, you might have decided to develop and run the system using the UCSD Pascal Operating System for your IBM PC and to write the code in Pascal. The requirements also should describe what the CRT (cathode-ray tube) display should look like and how players would enter moves.

As an example, consider a game we'll call Consumer. Consumer eats dots on a game board while being chased by demons. The game has three main operations: setting up the board, Consumer moves by a player, and moves by the demons chasing Consumer. Hence the initial specification might be that the main-program module has three other modules:

> Setup, which resets the display for a new game,
> Read_Move, which checks if the player has made a move, and
> Demon_Move, which generates moves for the demons and perhaps other objects like fruit.

Each of these three modules then can be broken down into simpler modules, to form a hierarchy of modules. The subdivision process stops when a module performs a single simple operation; for example, a module Update_CRT, which draws a character at some point on the display. The final specification might evolve to look like the structure diagram in figure 1. A structure diagram is not the same as a flowchart. A flowchart shows the decisions and operations within a module. A structure diagram shows the relationship between modules.

All interfaces, or data passed between modules, should be included in the specification. For example, the interface for the module Update_CRT might look like the one shown in figure 2.

DESIGN—ALGORITHMS AND DATA STRUCTURES

Once you have divided the system into

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Once you have a good design, coding should be the easiest part of the entire project.

a hierarchy of modules, you can design each module. Shared data structures should be designed first, using a high-level description showing how the data is accessed. In selecting algorithms and data structures it is important that you pick the simplest workable approach. Often, designers are tempted to choose the fanciest or most efficient designs, which invariably take longer to code, test, and debug than simpler designs.

For example, the board for Consumer could be stored in a two-dimensional array of characters, where C denoted Consumer, W denoted a wall, etc. However, a hacker determined to save space might have encoded the walls as a two-dimensional packed array of Booleans, where 0 denotes a corridor and 1 denotes a wall. The position of the Consumer, demons, etc., could all be stored in a short list of coordinates, thus saving hundreds of bytes of space. Unfortunately, the code to move Consumer and the demons is now much more complex and bug prone.

Once the system is up and running you can always go back and determine the most inefficient parts of the system and recode them. High-level language compilers are smart; don't try to do their jobs for them if you don't have to.

A good *profiler* helps determine where your program is wasting its time. Such programs can reveal the percentage of processor time spent in each routine, giving you a guide to what needs to be optimized (rewritten in assembly language, if necessary). However, profiles can be deceptive. Most microcomputer programs are I/O bound, so faster I/O may be the key to improved performance.

CODING

Once you have a good design, coding should be the easiest part of the entire project (assuming you already know the programming language you are using—don't try to learn to use a programming language by starting on a large software project).

Naturally, you should try to use good programming style, such as meaningful identifier names, clear and consistent indentation, short simple procedures, etc. If the language makes it difficult to use good programming style, then you

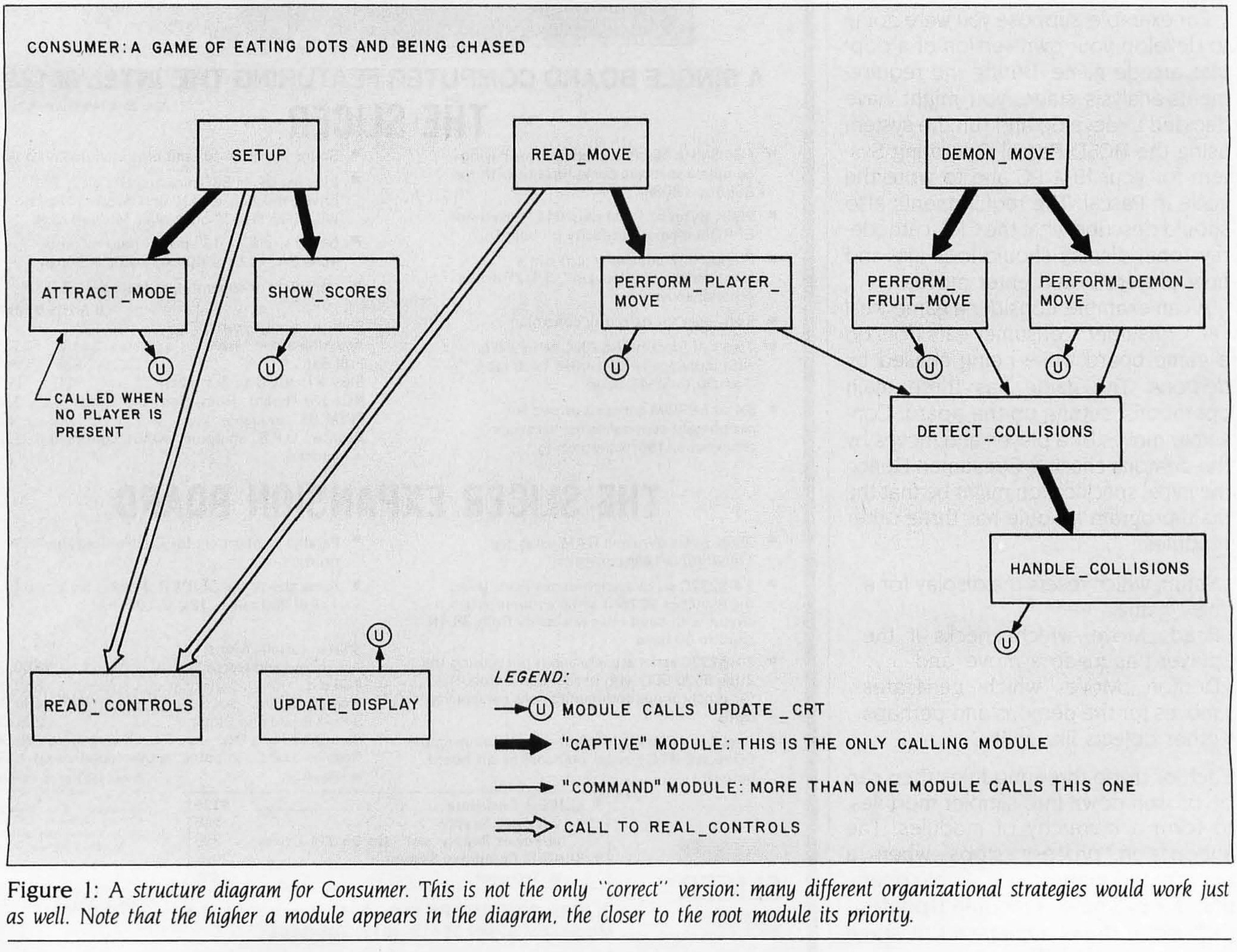

Figure 1: *A structure diagram for Consumer. This is not the only "correct" version: many different organizational strategies would work just as well. Note that the higher a module appears in the diagram, the closer to the root module its priority.*

probably have chosen the wrong language.

Sometimes the major frustrations of coding come from the compiler's limitations. Most microcomputer compilers have severe limitations on the maximum size of programs they can handle, and they may mysteriously "blow up" near the end of a long compilation if you have too many identifiers, procedures, or nested loops. Try to use separate compilation and avoid monolithic programs.

On a large project you should avoid using programming "tricks" such as writing lots of assembly-language subroutines to make your code fast, or using overlays (reusing memory to save space). Debugging and maintaining tricky code is very difficult. And microcomputers are becoming faster with more memory, so the tricks may be unnecessary if you just upgrade your hardware.

Update_CRT

Description: Draws a new char at location (*x*-coord,*y*-coord) on the screen. (0,0) is the top left-hand corner and (23,79) is the bottom right-hand corner.

Parameters:

DIRECTION	NAME	DESCRIPTION
IN	*x*_coord:	the *x*-coordinate for the character
IN	*y*_coord:	the *y*-coordinate for the character
IN	symbol:	character to draw on the screen
OUT	ok:	false if the character could not be output at (*x*-coord,*y*-coord)

Figure 2: *The Update_CRT interface.*

TESTING

Testing is much easier if you test each component of the software separately. For example, in developing Consumer you first should test the routine Update_CRT, then Setup, etc. Such incremental testing makes it much easier to locate bugs when they occur.

Usually it is impossible to test every combination of inputs and events (imagine trying to test every possible move on every possible game board). The best approach is to test a selection of inputs including all exceptional cases, such as two demons colliding.

Once you have uncovered, or "localized," a bug in a particular module, there are two approaches to correcting the bug. The first is to make the minimum change in the code necessary to correct the error. This approach works well when the bug is small, simple, and localized, such as a typographical error.

The second way to correct a bug is to rewrite the entire module. If the bug is subtle or caused by design flaws or tricky code, then it may be better to recode the module. If it has been a long time since you wrote the module and it is poorly documented, then it may be easier to recode than to try to understand what the code is doing.

Never let your sense of pride prevent you from throwing out poor code. The tricky bug you managed to correct may not be the last or, worse, may introduce other subtle bugs.

One of the best strategies for testing is to get a friend to use your software after you are convinced it is working (in industry this is known as beta testing). Do this as early as you can. Often another person will attempt to use your software in ways you would never have expected and consequently uncover more bugs for you.

MAINTENANCE

Maintenance consists of adapting the software to new environments (new user requirements, new hardware, or new software) and fixing bugs not found during testing (or ignoring them by considering them undocumented "features" of the software).

Even if you only intend to use the software yourself, you may face maintenance problems, such as moving your software to a new microcomputer. Maintenance of major commercial software products is a complex, expensive operation, involving hotlines for angry users, bug reports and fixes, and new versions and releases.

Fortunately, you can minimize the time you need to spend in maintaining software by following three simple principles.

First, document *everything* you do *immediately*! Documentation is not something you should ignore until the project is over or it will never get done properly. Documentation includes not only the user manual but also the design diagrams and design changes, commented code and data structures, and a progress log of testing and bug fixes. Without good documentation it is difficult for even the original software developer to remember how to modify the code or fix bugs easily without introducing new bugs. It's almost impossible for anyone else to do the job.

Second, do a thorough job of designing, coding, and testing in the first place.

And third, keep all your old test data and try every modified version of the software on all the old test data to make sure everything still works.

If your software is to be marketed it is important to try to make the user interface foolproof and to provide good documentation for novice users.

WHAT NOW?

There is much more to the subject of software engineering than we've covered here. Many software-engineering techniques are mainly useful for large commercial projects. However, by learning more about the techniques applicable to microcomputer software projects, you can increase the chance of being successful in projects you undertake. The books listed in the References section provide good guidelines for developing software. Unfortunately, there is no one "software engineering bible" that contains everything you need to know, so you will have to pick and choose. Most of the books listed are in fairly wide circulation and are probably available in college libraries and bookstores. ■

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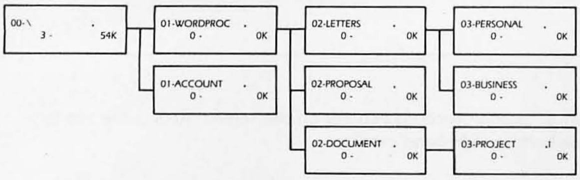

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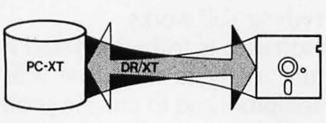

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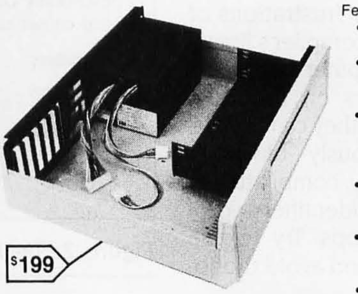

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Computer Graphics Theory and Applications, Tosiyasu L. Kunii, ed. New York: Springer-Verlag, 1983; 542 pages, 17 by 25 cm, hardcover, ISBN 0-387-70001-3, $45.

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THE FIRST FAMILY COMPUTER BOOK, Ed & Stevie Baldwin and K. Bruce Fingerle. Radnor, PA: Chilton Book Co., 1984; 240 pages, 18.5 by 22.8 cm, softcover, ISBN 0-8019-7498-4, $12.95.

THE FUTURE OF VIDEOTEXT, Efrem Sigel. Englewood Cliffs, NJ: Prentice-Hall, 1983; 208 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-345769-9, $9.95.

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(continued)

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PROGRAMMING INSIGHT

DICTIONARY COMPRESSION AND DECOMPRESSION

BY ERIC DUNN

An elegant algorithm

RECENTLY, I FACED the problem of developing an algorithm for manipulating a dictionary in computer-readable form. As you can imagine, standard ASCII (American National Standard Code for Information Interchange) text files for even a small dictionary can consume a lot of storage space. I needed a method for storing large numbers of alphabetically sorted words as efficiently as possible.

I approached the problem with two goals: (1) to find a fast and simple algorithm able to reduce a dictionary to a compact form and then reconstruct it, and (2) to choose a compression scheme that produces a compressed file that is directly printable and editable as ordinary ASCII text.

Both these goals argued against schemes that reduce the number of bits used to represent an individual character. (Early teletypes, for example, used just five bits to code the alphabet and common punctuation.) Instead, I chose an algorithm that takes advantage of the fact that words in a dictionary, being in alphabetical order, tend to start with the same letters as their neighboring entries.

The compression scheme works as follows: each word in the compressed dictionary starts with a digit that indicates how many characters should be copied from the preceding word in the dictionary. The rest of the letters for the word follow the digit. (The range of digits from 0 to 9 is extended in ASCII sequence with a colon (:) interpreted as 10, a semicolon (;) interpreted as 11, and so on.) For example, if the original dictionary contained only three words:

ant<CR><LF>
apple<CR><LF>
application<CR><LF>

it would be compressed as follows:

0ant1pple4ication<CR><LF>

The words are output on one line until a prespecified right margin is reached, so an additional savings of space is achieved from needing fewer <CR><LF> pairs. Note that the compressed words are still legible, after a fashion.

The C-language program Compr (see listing 1) carries out this compression algorithm on alphabetically ordered ASCII text files with one word per line. The dictionary must be all lowercase or all uppercase. The complementary program Dcomp (see listing 2) performs the inverse function—it produces an ASCII text file with one word per line from a file that has been compressed by Compr.

In the example shown above, the original dictionary contains 25 characters and the compressed version contains 19, for a space savings of only 24 percent. In practice, though, entries in an actual dictionary will be much closer to each other, lexicographically speaking, than those in this example, and the savings greater. In a dictionary of about 3000 words, I have observed a space savings of about 50 percent. With a larger dictionary, the compression ratio is even greater.

Naturally, if the goal of keeping the dictionary in readable form were abandoned, significant further reductions could be obtained. For example, representing characters and digits as six bits and eliminating all <CR><LF> pairs would compress the dictionary an additional 25 percent or more. Even fur-

(continued)

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Listing 1: *The Compr program.*

```
/* COMPR */
/*****************************************************************/
/* Reads an alphabetized file (1 word per line) from stdin.     */
/* Writes a compressed version of the file on stdout.           */
/*                                                               */
/* Words in the output file are preceded by a count of          */
/* characters identical to the previous word + an offset        */
/* of 48 (ASCII '0'), and these identical characters are        */
/* omitted. Multiple words are output on each line until        */
/* column OUTWIDTH is reached; at this point, the current       */
/* word is made the last on the line by printing '/n'           */
/*                                                               */
/*****************************************************************/

#include <stdio.h>


#define INWIDTH 80
#define OUTWIDTH 60

/* INWIDTH is the maximum length of an input line          */
/* OUTWIDTH is the last column on which an output word will start */

main ()
{

char     save[INWIDTH];          /* Storage for previous word read */
char     word[INWIDTH];          /* Holds current words */
register char *s;                /* Pointer to current word */
register char *t;                /* Pointer to previous word */
int      chrcount;               /* Count of chrs same in 'save' and 'buffer' */
int      linelen;                /* Length of output line */

save[0] = '\0';                  /* Initialize previous word to null */
linelen = 0;                     /* Initialize output line length as 0 */

while(gets(word))                                        /* Get a line from    */
        {                                                /* stdin(i.e. a word) */
        s=&word;t=&save;                                 /* Set pointers       */
        chrcount = 0;                                    /* Clear counter      */
while ((*t != 0) && (*s++ == *t++))                      /* Count ...          */
                chrcount++;                              /*  .. identical chrs */
        printf("%c%s",chrcount+'0',&word[chrcount]);     /* Print code & word  */
        linelen += 1 + strlen(&word[chrcount]);          /* Count output width */
        if (linelen >= OUTWIDTH)                         /* At right margin .. */
                {linelen = 0; printf("\n");}             /*  ... print CR      */
        strcpy(save,word);                               /* Save current word  */
        }
}
```

Listing 2: *The Dcomp program.*

```
/* DCOMP */
/*****************************************************************/
/* Reads a compressed file created by COMPR from stdin.         */
/* Writes a standard ASCII file to stdout, 1 word per line.     */
/*                                                               */
/*   DCOMP is a complementary program to COMPR that             */
/*   decompresses the input file produced by COMPR              */
/*   to restore the original file.                              */
/*                                                               */
/*****************************************************************/

#include <stdio.h>
```

```
#define INWIDTH 80

/* INWIDTH is the maximum length of an input line which is expected */

main ()
{
char  save[80];                          /* Storage for the previous word read */
char  word[80];                          /* Holds the current word */
int   samechr;                           /* Number of characters in word returned */
                                         /* by 'getw' identical to previous word */
save[0] = '\0';                          /* Initialize previous word to null */

while( (samechr = getw(&word)) >= 0)        /* Call 'getw' for a word           */
        {                                   /* (samechr < 0 means EOF)          */
        strcpy(&save[samechr],&word);       /* Add non-identical chrs on        */
        printf("%s\n",&save);               /* Print reconstructed word         */
        }
}

/* function GETW */
/*****************************************************************************/
/* Argument:  pointer to buffer to store a word                             */
/* Returns:    'No. of identical chars' code, or -1 if EOF                  */
/*                                                                           */
/* Reads stdin to get compressed input. Ignores '\n'                        */
/*****************************************************************************/

getw(t)
char *t;                                                  /* Ptr to word buffer*/

{
register int     chr,count;

    while ( (chr = getchar()) < 'A')        /* Find Ctrl, non-alpha chrs        */
            {                               /* Last such character . . .        */
            count = chr - '0';              /* . . . is compression count       */
            if (chr == EOF) return(-1);     /* If EOF, return -1                */
            }
    ungetc(chr,stdin);                      /* Put back the alpha char.         */
    while ( (chr = getchar()) >='A')        /* Copy word until . . .            */
            *t++ = chr;                     /* . . . a non-alpha is found       */
    ungetc(chr,stdin);                      /* Put back the non-alpha           */
    *t++ = '\0';                            /* Null-terminate the string        */
    return(count);                          /* Return the compress. count       */
}
```

With 26 pointers into the file, one to the start of the a's through one to the start of the z's, the dictionary can be searched quite rapidly.

ther compression could be achieved by using a variable-length code, allocating fewer bits for common characters, but such a scheme would be considerably more complex and would execute more slowly.

A limitation of the dictionary compression scheme is that in order to decompress a word from the dictionary, you have to know what the previous word is, whose decompression in turn depends on the next previous word, and so on. In practice, though, dictionary access is not limited to serial searches from the beginning, since the first word starting with a new letter copies no letters from its predecessor. Thus, with 26 pointers into the file, one to the start of the *a*'s through to one to the start of the *z*'s, the dictionary can be searched quite rapidly. This pointer scheme may be extended with an index to the start of each two-letter pair (*aa*, *ab* through *zy*, *zz*) so that even less of the dictionary must be read to look up a given word. ■


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BUILD A REAL-TIME MEMORY-ACTIVITY DISPLAY

BY ROBERT BARNS

Watch computer activity on an oscilloscope

A REAL-TIME MEMORY-ACTIVITY display is a simple attachment you can build for your microcomputer. Used with an oscilloscope, this device has several interesting applications. Here are some of the insights into memory activity possible when you can "see" your computer operating:

- You can see where a program loads into memory by visually observing the loading process.
- You can determine, at a glance, which machine-language routines are consuming the most time.
- The great complexity of apparently simple tasks is demonstrated.
- When troubleshooting your microcomputer proves difficult, this device can provide some useful clues to the cause of a problem.
- If your computer seems to have stopped for no discernible reason, you can see immediately what activity is going on.
- Certain types of programming errors can be seen.
- You can observe when monitor, DOS (disk operating system), buffer, page-zero, and stack routines are being used.

The principle behind this device is quite straightforward. Imagine a square array with 256 by 256 locations. This array contains 65,536 locations. The 256 positions along the *x*-axis represent individual memory locations in one page of memory and the 256 positions along the *y*-axis represent pages of memory (see figure 1).

If we superimpose this array of locations on an oscilloscope screen and create a bright spot on the screen every time each memory location is either read or written to, we can see, in real time, all of the activity in memory. This scheme is used in some highly expensive logic analyzers, but there is a simple and inexpensive way to approximate such a display. We need two 8-bit digital-to-analog (D/A) converters.

A D/A converter has one input for each digit of data. Its output is an analog voltage proportional to the value of the digital input. The 8-bit bytes of data in a microcomputer represent (decimal) values from 0 to 255. For this application, we need a D/A converter that produces about 5 volts when the binary input is 11111111 (255 decimal) and 0 volts when the data is 00000000. A value of 01111111 (127 decimal) then produces about 2.5 volts.

We then connect one D/A converter to the lowest 8 bits of the address bus and connect its output to the x-axis of an oscilloscope. The other D/A converter is connected to the highest 8 bits of the address bus and its output to the *y*-axis.

The electron beam in the oscilloscope now will deflect toward the right by an amount proportional to the value of the lowest 8 bits of the address and upward by an amount proportional to the highest 8 bits. The brightness of the spot on the screen is determined by how often each spot is selected.

Photo 1 shows a photograph of the oscilloscope screen while an Apple II+ is running the Grid program shown in listing 1. This program runs between hexadecimal locations 6060 and 606A and is seen as the bright band just below the screen center. The bright spots at the very bottom are references to zero-page locations FA and FB, the

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indirect addresses used to point to the memory locations to be accessed. The fainter dots that form the square array are the "output" of the program and occur when the program reads individual memory locations.

This square array of dots can be used to set the gain and position of the display on the oscilloscope to provide a "logical" calibration. I set my scope so that the horizontal lines of dots are about 1 centimeter (cm) apart on the screen, and, because there are nine dots, they indicate the position of pages 00, 20, 40, 60, 80, A0, C0, E0, and FF. This program also checks the correctness of your wiring because most wiring errors show up as dots located at points other than those in the square array. You can further verify your wiring by running the program in listing 2, which should produce a diagonal line of eight spots at an angle of 30 degrees.

While running one of these programs, increase the brightness on the scope and you will see some wiggly lines connecting the bright spots. These lines can be ignored; they are probably due to slight speed differences between the *x*- and *y*-axis sections of the D/A circuit.

I made a paper scale with labels 1 cm apart that I attached to the scope face. I also included the locations of the principal areas of memory on the scale. The *y*-axis scale for the Apple II+ is shown in figure 2. A scale for the *x*-axis should also be made.

THE HARDWARE

My first attempt at the complete D/A circuit used two inexpensive 8-bit Motorola D/A chips and a Radio Shack dual FET (field-effect transistor) operational amplifier (op amp). It worked poorly. I suspect that this arrangement is not fast enough. The circuit that works well uses an R-2R ladder with three 4050 hex CMOS (complementary metal-oxide semiconductor) buffers. CMOS gates have a well-defined output voltage (near the supply voltage), which is not true of TTL (transistor-transistor logic) gates.

Figure 3 is a schematic of the D/A converter circuit with the peripheral socket pin connections for an Apple II+. For other computers, connect these points to the indicated address lines.

The accuracy of the D/A converter (the

(continued)

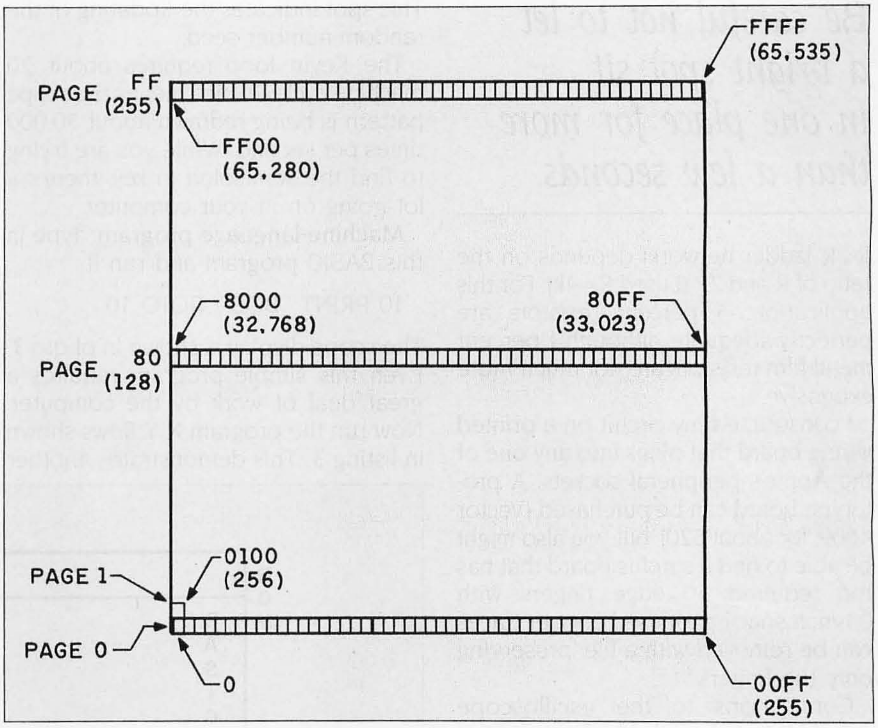


Figure 1: *The configuration of the memory-display array. Locations are given in hexadecimal and parenthetically in decimal.*

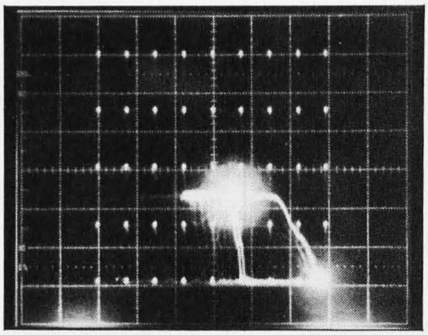


Photo 1: *The Grid program memory-activity display.*

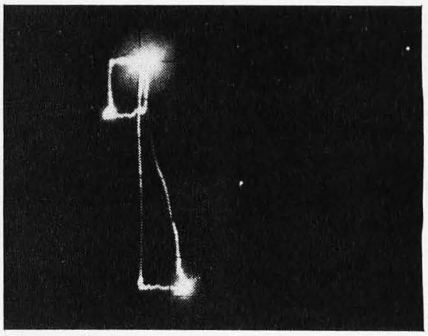


Photo 2: *The Keyin monitor routine memory-activity display.*

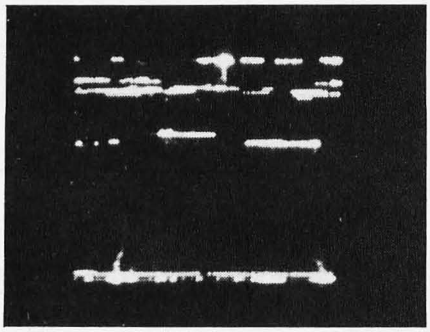


Photo 3: *The memory-activity display of a one-line BASIC program described in text.*

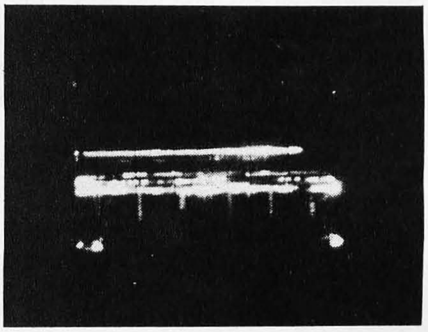


Photo 4: *The memory-activity display of the game Crossfire.*

> *Be careful not to let a bright spot sit in one place for more than a few seconds.*

R-2R ladder network) depends on the ratio of R and 2R (I used R=4k). For this application, 5 percent resistors are perfectly adequate, although 1 percent metal-film resistors are not much more expensive.

I constructed my circuit on a printed wiring board that plugs into any one of the Apple's peripheral sockets. A prototype board can be purchased (Vector 4609, for about $20), but you also might be able to find a surplus board that has the required 50-edge fingers with 0.1-inch spacing. Unused copper traces can be removed with a file, preserving only the fingers.

Connections to the oscilloscope should be made with 10× (attenuation by 10) probes to reduce the effect of probe capacitance. Set the scope for *x-y* display and adjust the intensity for a good display with the computer running, for example, the Grid program. You should be careful about the possibility of burning the screen by letting a bright spot sit in one place for more than a few seconds. If you turn off the computer, the high-intensity spot will sit at the lower left corner of the screen. The intensity control should be turned down until the computer is started again.

EXPERIMENTING

When you have checked out the hardware and can interpret the scope picture, here are some experiments you can try. Doing these may suggest others.

Keyin: A simple pattern, and the one you will see most often, is the one produced by the monitor routine Keyin. This pattern is shown in photo 2. This is always seen when the cursor is waiting, such as after the Applesoft, integer BASIC, or monitor prompt, and in many other instances. The uppermost bright spot is in the monitor at FD1B. The smaller one to the left is at C000 where the keyboard port is checked, and the bottom spot is at 004F in page zero. This spot indicates the updating of the random-number seed.

The Keyin loop requires about 20 machine cycles, which means the scope pattern is being redrawn about 50,000 times per second. While you are trying to find the semicolon (;) key, there's a lot going on in your computer.

Machine-language program: Type in this BASIC program and run it.

```
10 PRINT "BOB";:GOTO 10
```

The scope display is shown in photo 3. Even this simple program requires a great deal of work by the computer. Now run the program X Y Rows shown in listing 3. This demonstrates another BASIC program, one that includes a machine-language subroutine. The program uses POKE commands to insert jump instructions into memory locations starting at 8000 and going across a page at equal intervals. It then calls the first jump instruction 200 times, repeating at 7000, 6000, and so on, down to 1000. The execution of the machine-language instructions will be seen as a succession of horizontal lines of dots moving down the scope screen.

Booting a DOS: It is interesting to watch a DOS being booted. The process happens so fast that it may take you several trials to see most of it, but look

(continued)

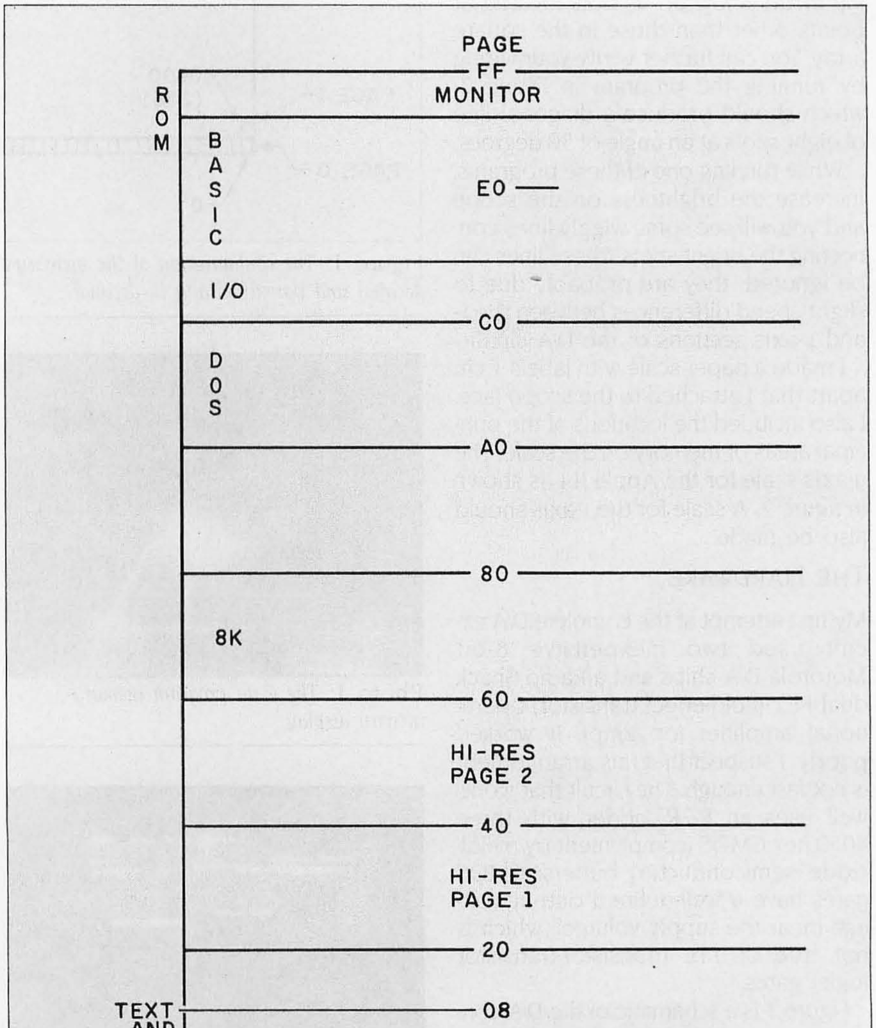


Figure 2: *The y-axis paper scale used to label the Apple II+ memory-location display.*

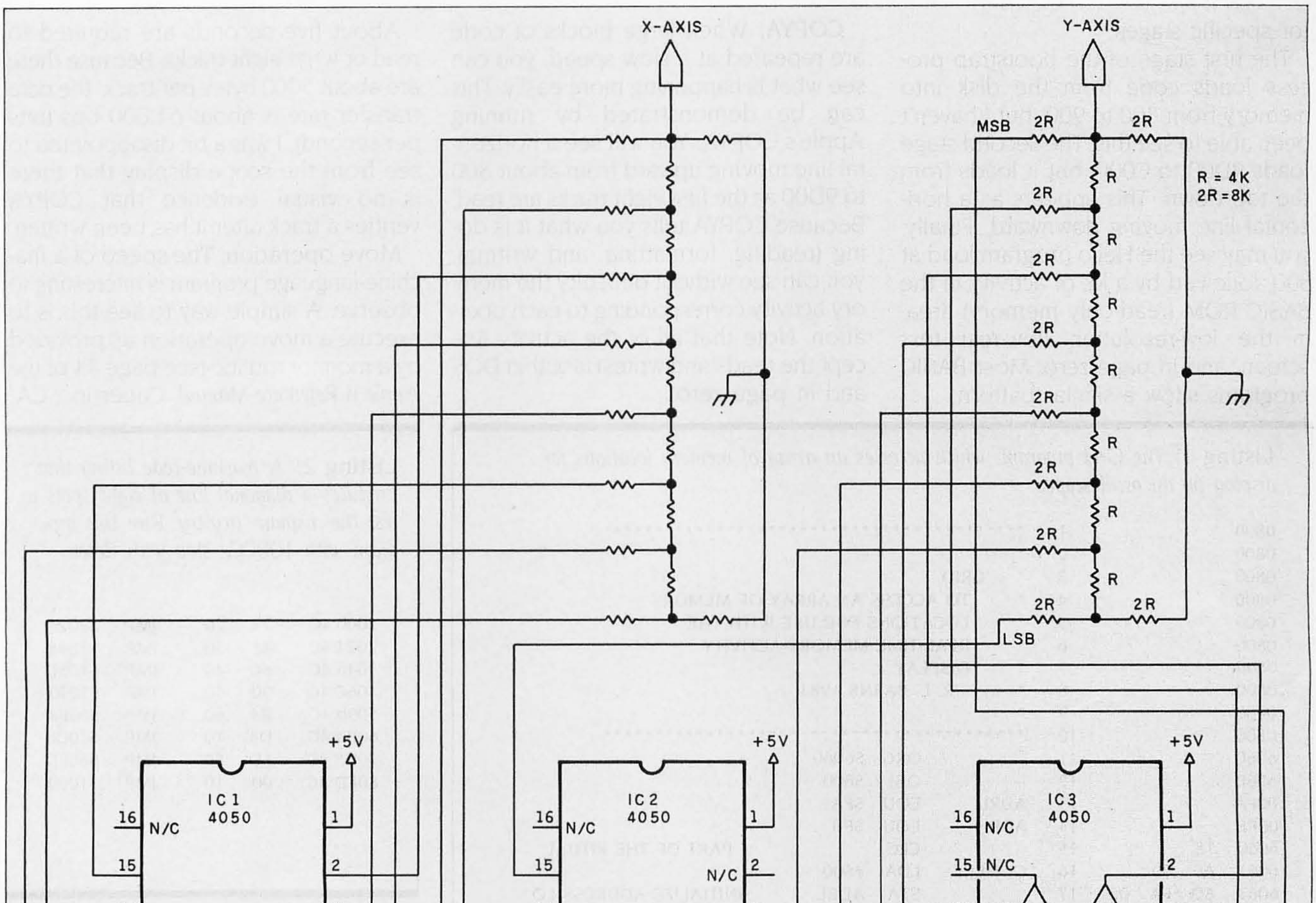


Figure 3: *The D/A converter schematic diagram.*

for specific stages.

The first stage of the bootstrap process loads code from the disk into memory from 800 to 900, but I haven't been able to see this. The second stage loads 9D00 to C000, but it loads from the top down. This appears as a horizontal line moving downward. Finally, you may see the Hello program load at 800, followed by a lot of activity in the BASIC ROM (read-only memory) area, in the low-resolution (low-res) text screen, and in page zero. Most BASIC programs show a similar pattern.

COPYA: When large blocks of code are repeated at a slow speed, you can see what is happening more easily. This can be demonstrated by running Apple's COPYA. You will see a horizontal line moving upward from about 800 to 9D00 as the first eight tracks are read. Because COPYA tells you what it is doing (reading, formatting, and writing), you can see without difficulty the memory activity corresponding to each operation. Note that all of the activity (except the reads and writes) is within DOS and in page zero.

About five seconds are required to read or write eight tracks. Because there are about 5000 bytes per track, the data transfer rate is about 64,000 bps (bits per second). I was a bit disappointed to see from the scope display that there is no visual evidence that COPYA verifies a track after it has been written.

Move operation: The speed of a machine-language program is interesting to observe. A simple way to see this is to execute a move operation as provided by a monitor routine (see page 44 of the *Apple II Reference Manual*, Cupertino, CA:

Listing 1: *The Grid program, which accesses an array of memory locations for display on an oscilloscope.*

```
0800                 ***************************************
0800                 *
0800                 *    GRID
0800                 *      TO ACCESS AN ARRAY OF MEMORY
0800                 *      LOCATIONS FOR USE WITH THE
0800                 *      REAL-TIME MEMORY-ACTIVITY
0800                 *      DISPLAY
0800                 *        R. L. BARNS 1983
0800                 *
0800                 ***************************************
6060                          ORG  $6060
6060                          OBJ  $800
00FA                 ADRL     EQU  $FA
00FB                 ADRH     EQU  $FB
6060  18                      CLC              ;  PART OF THE RITUAL
6061  A9  00         GOHERE   LDA  #$00
6063  8D  FA  00              STA  ADRL        ; INITIALIZE ADDRESS LO
6066  8D  FB  00              STA  ADRH        ;        DITTO       HI
6069  20  90  60              JSR  DOIT        ; DO PG. 0 AND 20


606C  A9  40                  LDA  #$40        ; ADDR FOR NEXT TWO LINES
606E  8D  FB  00              STA  ADRH
6071  20  90  60              JSR  DOIT
6074  A9  80                  LDA  #$80        ; DO PG. 80 AND A0
6076  8D  FB  00              STA  ADRH
6079  20  90  60              JSR  DOIT
607C  A9  C0                  LDA  #$C0
607E  8D  FB  00              STA  ADRH
6081  20  90  60              JSR  DOIT
6084  A9  FF                  LDA  #$FF        ; DO TOP LINE
6086  8D  FB  00     NEWPG    STA  ADRH
6089  20  90  60              JSR  DOIT
608C  4C  61  60              JMP  GOHERE      ; RUN FOREVER(UNTIL RESET)
608F  00                      BRK
6090  A0  00         DOIT     LDY  #$00        ; INITIALIZE Y
6092  18                      CLC              ; GET READY FOR ADDITION
6093  B1  FA         NEXT     LDA  ($FA),Y     ; ACCESS THE MEM. LOC.
6095  A5  FA                  LDA  $FA
6097  69  20                  ADC  #$20        ; BUMP ADDR BY 20 PAGES
6099  85  FA                  STA  $FA
609B  B0  04                  BCS  LSTLOC      ; ALMOST DONE?
609D  4C  93  60              JMP  NEXT        ; NO, DO SOME MORE
60A0  60                      RTS              ; YES, RTN. TO MAIN PROG.
60A1  A0  FF         LSTLOC   LDY  #$FF        ; DO TOP LINE OF DISPLAY
60A3  B1  FA                  LDA  ($FA),Y
60A5  60                      RTS
60A6                          END

***** END OF ASSEMBLY
```

Listing 2: *A machine-code listing that produces a diagonal line of eight spots to test the display circuitry. Run this program with* 1000G; *stop with* Reset.

```
1000:4C   24   20     JMP   $2024
2024:4C   48   30     JMP   $3048
3048:4C   6C   40     JMP   $406C
406C:4C   90   50     JMP   $5090
5090:4C   B4   60     JMP   $60B4
60B4:4C   D8   70     JMP   $70D8
70D8:4C   FD   80     JMP   $80FD
80FD:4C   00   10     JMP   $1000
```

Listing 3: *A display-demonstration program that includes a machine-language call routine.*

```
100  For M = 8 To 1 Step -1
120       D = 0
140       I = 16
160       AA = 4096*M
180       A = AA
          B = AA+1
          C = AA+2
200       If D+1>255 Goto 320
220       Poke A,76
240       Poke B,D+1
260       Poke C,16*AA/4096
280       A = A+1
          B = B+1
          C = C+1
          D = D+1
300          Goto 200
320       Poke A-1,96
340       For R = 1 To 200
360            Call AA
380       Next R
400  Next M
420      Goto 100
```

When large blocks of code are repeated at slow speed, you can more easily see what is happening.

Apple Computer Inc., 1979).

Go to the monitor with the statement CALL – 151. Type 4000<0000.4000M (without any spaces) and watch the scope while you hit Return. Two horizontal lines moving upward will appear. The lower one is the memory being read, and the upper one is the memory being written. This move of 16,384 bytes takes about 1.5 seconds, which gives a transfer rate of about 87,000 bps. You will also see that, in addition to the monitor routine, page zero is used.

Memory overwrite: Load Applewriter II and then bring up the menu with Control-Q. Select 0 (quit), answer Y (yes), and watch the scope. You will see a fast wipeout of all of memory including DOS. I also have seen other programs do this, and I suppose that it is part of the scheme to prevent copying. Applewriter seems to overdo it, though, because it tries to overwrite ROM too.

Some potential dangers exist in overwriting all of memory; writing to the I/O (input/output) area (from C000 to CFFF) might set some soft switches or some peripheral cards to wrong values.

Game programs: Finally, run some of your favorite games and watch the scope. Photo 4 shows the memory activity while Crossfire is running its demo. Three bright spots are in page zero. Above them are seven parallel vertical bars. These bars are in the high-resolution (hi-res) graphics page, and they flicker and move as various features of the screen are written.

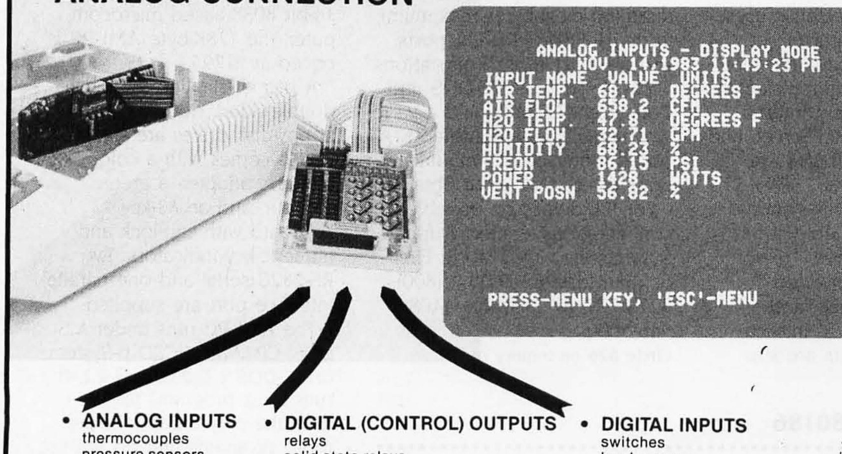
Pac Man is also a good example. You can see where the code is running as well as frantic activity on hi-res page one.

Another interesting game to run is Falcons. You will see a prominent bar in the hi-res page as the formations of bogeys move from side to side. The patterns produced by the spectacular sound effects also are clearly visible.

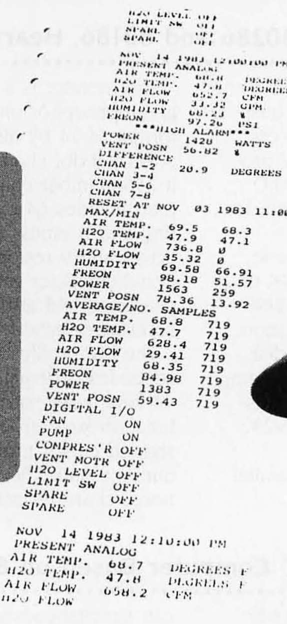
SUMMARY

While this project in no way can compete with commercial logic analyzers, it does, nonetheless, provide an inexpensive means of "viewing" the activity within your microcomputer. As you experiment, perhaps other uses will become apparent. ■

ACKNOWLEDGMENT
The author wishes to thank David Horn for suggesting this memory-activity display and for his lucid description of the R-2R ladder network.



```
ANALOG INPUTS - DISPLAY MODE
       NOV 14,1983 11:49:23 PM
INPUT NAME   VALUE   UNITS
AIR TEMP.    68.7    DEGREES F
AIR FLOW     658.2   CFM
H2O TEMP.    47.8    DEGREES F
H2O FLOW     32.71   GPM
HUMIDITY     68.23   %
FREON        86.15   PSI
POWER        1428    WATTS
VENT POSN    56.82   %

PRESS-MENU KEY, 'ESC'-MENU
```

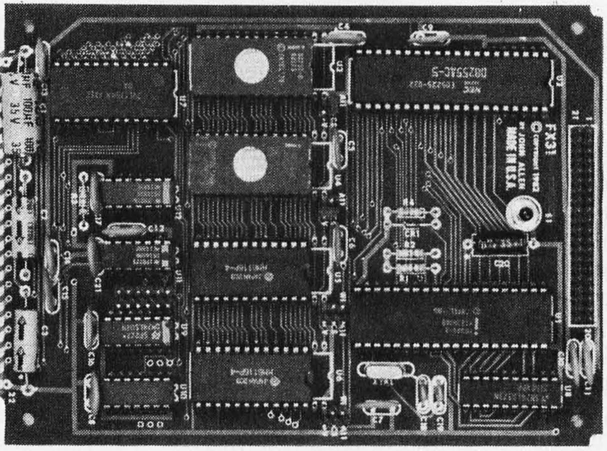


```
H2O LEVEL  OFF
LIMIT SW   OFF
SPARE      OFF
SPARE      OFF

NOV  14 1983 12:00:00 PM
PRESENT ANALOG
AIR TEMP.   68.8    DEGREES F
H2O TEMP.   47.8    DEGREES F
AIR FLOW    652.7   CFM
H2O FLOW    33.32   GPM
HUMIDITY    68.23   %
FREON       97.26   PSI
     ***HIGH ALARM***
POWER       1428    WATTS
VENT POSN   56.82   %
DIFFERENCE
CHAN 1-2    20.9    DEGREES F
CHAN 3-4
CHAN 5-6
CHAN 7-8
RESET AT NOV  03 1983 11:00:00 AM
MAX/MIN
AIR TEMP.   69.5    68.3
H2O TEMP.   47.9    47.1
AIR FLOW    736.8   0
H2O FLOW    35.32   0
HUMIDITY    69.58   66.91
FREON       98.18   51.57
POWER       1563    259
VENT POSN   78.36   13.92
AVERAGE/NO. SAMPLES
AIR TEMP.   68.8    719
H2O TEMP.   47.7    719
AIR FLOW    628.4   719
H2O FLOW    29.41   719
HUMIDITY    68.35   719
FREON       84.98   719
POWER       1383    719
VENT POSN   59.43   719
DIGITAL I/O
FAN         ON
PUMP        ON
COMPRES'R   OFF
VENT MOTR   OFF
H2O LEVEL   OFF
LIMIT SW    OFF
SPARE       OFF
SPARE       OFF

NOV  14 1983 12:10:00 PM
PRESENT ANALOG
AIR TEMP.   68.7    DEGREES F
H2O TEMP.   47.8    DEGREES F
AIR FLOW    658.2   CFM
H2O FLOW
```

NEW SYSTEMS

8031-Based Single-Board Computer

The FX-31 single-board computer from Allen Systems is based on the 8031 microprocessor, which is a ROMless 8051 chip. The 8031 comes with a full-duplex UART, two 16-bit counter/timers, a Boolean processor, two 8-bit parallel ports, 128 bytes of RAM, hardware multiply and divide, and a 1-microsecond cycle time.



In addition to the 8031, the FX-31 comes with three parallel ports, RS-232C buffering, and up to four 24- or 28-pin JEDEC memory devices. Memory abilities comprise up to 32K bytes of EPROM or RAM on the JEDECs. Two of the JEDECs must be EPROM; the other two can be EPROM or RAM.

Its serial I/O provides both TTL- and RS-232C-level communication. Its 2- by 20-pin I/O connector brings out the four parallel ports, TTL and RS-232C serial data, and a +5-V ground.

The FX-31 measures 4½ by 6½ inches. Board expansion is available by means of a 22/44-pin finger connector. The finger connector brings out all processor lines, including address, data, and control, and the board's power connection. Power requirements are +5 V at 500 mA, +12 V at 50 mA, and −12 V at 50 mA.

A variety of optional software packages for development and applications is available. The SM-31 System Monitor EPROM is $30. A TB-31 tiny-BASIC EPROM is priced at $40, and the SX-51 Apple II-based 8051 cross-assembler can be purchased for $60.

The FX-31 is available from stock within four weeks. A bare board with documentation is $30, while a kit version with 4K bytes of EPROM and a 2K-byte RAM is priced at $125. Assembled and tested, it's $160. For more information, contact Allen Systems, 2151 Fairfax Rd., Columbia, OH 43221, (614) 488-7122.

Circle 625 on inquiry card.

Dual Processors, 80286 and 80186, Heart of Poppy

Durango has announced the Poppy II multiuser business computer, which incorporates an 80286 central processor and an 80186 for I/O control and port expansion for up to 12 users.

Priced at $9975, the basic Poppy II comes with 384K or 640K bytes of RAM, an 819K-byte floppy-disk drive, a monitor, a 10-megabyte hard-disk drive, and the XENIX operating system. A choice of transmission protocols for the RS-232/RS-422 is offered, and a Centronics-compatible parallel I/O port is standard.

The monitor is a 14-inch P-31 green-phosphor unit with a format of 24 by 80 or 132 and a 7- by 9-dot character. It uses a 256-member character set that includes 64 extended plotting and business graphics characters and 9 resident international character sets. Screen and character-field attributes are software-selectable.

The low-profile DIN-standard keyboard is detachable. It has 94 keys, *n*-key rollover, 16 soft function keys, an inverted T-shaped cursor group, and a numeric pad. The 10 international character sets are supported by key-top changes only.

Options include three additional 10- or 20-megabyte hard disks (60 megabytes maximum), up to 11 RS-232/RS-422 ports, and up to 11 more workstations. Software such as MS-DOS and Concurrent CP/M-86 and a variety of languages are available. A serial printer and communications protocols can be obtained.

For full details on possible configurations, contact Durango Systems Inc., 3003 North First St., San Jose, CA 95134, (800) 327-6779; in California, (408) 946-5000.

Circle 626 on inquiry card.

Single-Board S-100 Computer Based on 80186

The Super 186 is a 16-bit S-100 single-board computer constructed around Intel's 80186 microprocessor. It can be configured as a stand-alone bus master or as a bus slave to serve single and multiple users.

It comes with 256K bytes of RAM, expandable to 1 megabyte. Its floppy-disk controller can simultaneously support both 5¼- and 8-inch drives. Four serial RS-232C and two parallel ports are standard. It's supplied with a DMA controller, parity, and a monitor EPROM.

Super 186 is compatible with CP/M-86, Concurrent CP/M, and TurboDOS, and it will emulate PC-DOS and MS-DOS. Under TurboDOS, it can function as an 8-/16-bit bus slave.

The suggested retail price is $1995. Quantity discounts are available. For details, contact Advanced Digital Corp., 5432 Production Dr., Huntington Beach, CA 92649, (714) 891-4004.

Circle 627 on inquiry card.

Low-Cost PC Compatible

American Micronics' AMI PC is nearly 100 percent compatible with the IBM PC. A 16-bit 8088-based microcomputer, the 128K-byte AMI PC is priced at $1795.

A pair of slimline 320K-byte double-sided, double-density floppy-disk drives are standard. It also comes with a color graphics adapter, a green monitor, and an 83-key keyboard with cap-lock and numeric-key indicators. Two RS-232C serial and one parallel interface port are supplied.

The AMI PC runs under MS-DOS, CP/M-86, UCSD p-System, or PC-DOS 1.1, 2.0, and 2.1. It runs most programs for the IBM; the only exceptions are those programs that do not use normal BIOS call routines.

A second parallel port that rides on top of the floppy-disk controller and hard-disk drives with capacities of 5, 10, or 15 megabytes are optional. Contact American Micronics Inc., Suite H, 17811 Skypark Circle, Irvine, CA 92714, (714) 261-2428.

Circle 628 on inquiry card.

NEW SYSTEMS

Computer Trio Targeted at System Integrators

International Quartz Ltd. has introduced a trio of 16-bit computers aimed toward OEM, system integrators, and third-party resellers. The line, comprising a notebook computer and two portables, is based on Intel's 80186 microprocessor. All units come with 128K bytes of RAM, upgradable to 640K bytes, two RS-232C serial ports, and a Centronics-type parallel interface.

The Model 9240 notebook computer features a 25-line LCD and a 360K-byte floppy-disk drive. It measures 15⅖ by 12⅕ by 3½ inches. A strap-on printer is optional.

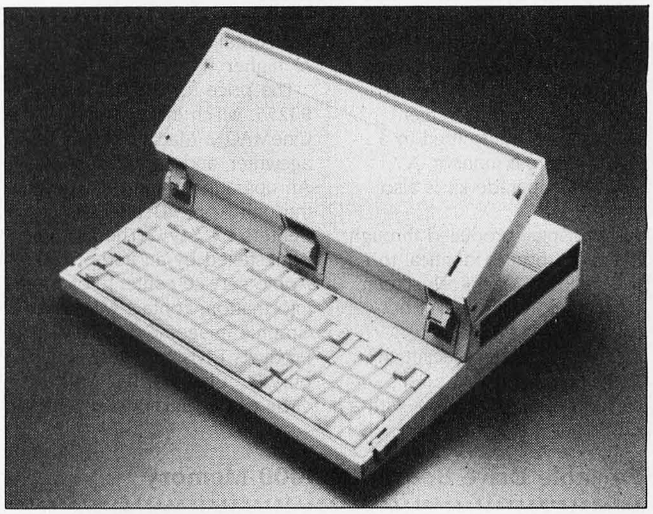
With two 360K-byte floppy-disk drives and the 25-line LCD, the Model 9230 portable computer comes with a built-in 80-column dot-matrix printer. It has a detachable, intelligent keyboard with a 3-line LCD that displays computer functions. This IBM PC-compatible keyboard is powered by six 1.5-volt AA-size rechargeable nicad batteries. The central processor is the Hitachi CMOS HD 6303R, augmented by 8K bytes of CMOS RAM.

A word processor is built into firmware, and its function keys are user-definable. An optional ROM/RAM cartridge provides the Model 9230 with extra memory or storage. Other options include a built-in modem. Its dimensions are 18⁹⁄₁₀ by 13⅘ by 9⁷⁄₁₀ inches; it weighs less than 35 pounds.

The Model 9231 comes with a CRT display and two 360K-byte floppy-disk drives. It's available with or without the intelligent keyboard. Weighing the same as the Model 9230, its dimensions are slightly smaller.

International Quartz Ltd. is located at 24-26 Sze Shan St., Yau Tong, Kowloon, Hong Kong; tel: 852 3-403769; Telex: 35454 XTAL HX. In the United States, contact Jack Carroll, 23505 Crenshaw Blvd., Torrance, CA 90505, (213) 539-8944.

Circle 629 on inquiry card.



The Model 9240 notebook computer.

PERIPHERALS

Eight Sensors Monitor Temperature

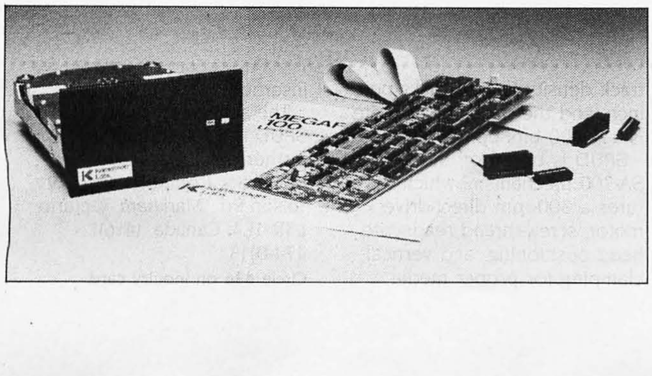
The Sabre Temperature Monitoring and Management System is available from the Temptron Systems Division of Bear Electronics Corporation. This multifunction, multiprogrammable system gathers data from eight all-weather temperature sensors that can be positioned up to 1000 feet away from the control console. Sabre combines software, the temperature sensors, and a microprocessor-based component board with nine separately controlled relays. The sensors are accurate to within ±1 degree Fahrenheit. The system is said to be particularly suitable for such applications as energy consumption and conservation and solar energy management.

The software lets you program several parameters for each sensor. Three of the parameters program the control ports; the other four parameters are location, minimum and maximum temperature, and delay time.

The Sabre System is currently available for the Apple II series and will soon support the IBM PC and the Radio Shack TRS-80. It requires 64K bytes of memory, an RS-232C serial I/O port, and an 80-character card. A tested system costs $495. Contact Temptron Systems, Suite F, 1595 West Amador, POB 16008, Las Cruces, NM 88005, (505) 524-9531; or for orders only, (800) 824-7888, operator 603.

Circle 630 on inquiry card.

Low-Cost 10-Megabyte Disk



The Megaflight 100 is a 10-megabyte IBM PC and PC-compatible hard-disk drive that sells for $895. It uses PC-DOS 2.0 or 2.1 software drivers, which gives it full compatibility with most IBM PC and PC XT software, including Lotus 1-2-3 and MicroPro WordStar.

Megaflight has low power; it typically does not require an external power supply. It is supplied with a manual that defines the disk format and I/O and provides installation instructions. Installation is said to require approximately 20 minutes.

For more information, contact Kamerman Labs, 7787 Southwest Cirrus Dr., Beaverton, OR 97005, (800) 522-2237; in Oregon (503) 626-6877.

Circle 631 on inquiry card.

(continued)

PERIPHERALS

Internal Video Port Provides External Mac Monitor

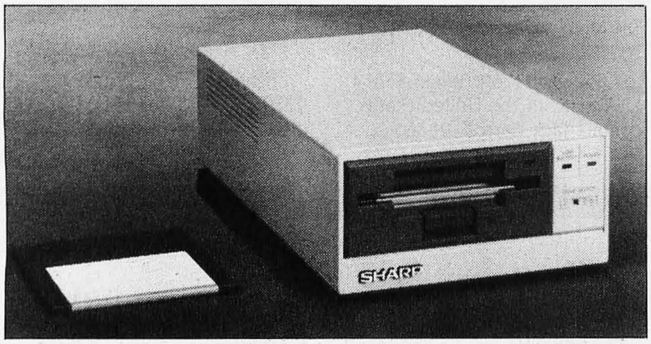
The CineMAC is a standard Apple Macintosh computer with an added internal video port that allows the screen image to be transmitted to a larger external monitor. A CineMAC upgrade kit is also available.

The display produced through the video port is identical to the standard Macintosh screen, differing only in size. All portions of the CineMAC are located inside the Macintosh. The video signal can be displayed on most monitors with a horizontal scan rate of 22 kHz or higher.

The price for the full system is $3255, which includes the CineMAC, a Macintosh, the Imagewriter, and an accessory kit. An upgrade kit can be ordered through Apple Dealer/Service Centers for $195. (The kit must be installed by an authorized Apple service center.) For more information, contact Micro-Graphic Images Corp., New Products Division, 19612 Kingsbury St., Chatsworth, CA 91311.

Circle 632 on inquiry card.

Portable Drive Boosts PC-5000 Memory



The CE-513F is a portable microfloppy-disk drive for Sharp Electronics' PC-5000 portable computer. Weighing 6 pounds and measuring 5⅗ by 2⅗ by 8⅘ inches, the CE-513F adds 360K bytes of formatted storage (500K unformatted) to the 128K bytes of bubble memory built into the PC-5000.

This drive uses double-sided, double-density disks, with nine sectors per track and 80 tracks overall. An optional rechargeable battery gives you one hour of continuous use, and the drive will operate off the standard PC-5000 AC-power adapter.

The CE-513F costs $699. Contact Sharp Electronics Corp., Systems Division, 10 Sharp Plaza, Paramus, NJ 07652, (201) 265-5600.

Circle 634 on inquiry card.

Emulator Port for PC XT

Kontron Electronics has introduced an emulator port that converts the IBM PC XT into a universal development system for the design, testing, debugging, and implementation of hardware and software.

The Kontron PC Interface is made up of hardware and a set of development-support software that includes a cross-assembler, linker, emulation software, and CP/M utilities. An optional emulator subsystem and Pascal compiler are available.

Programmers can use the Pascal compiler or the assembler to process edited source text. The source-text processors can develop object code for various microprocessors including the Z80, MC68000, 8086/8088, and 80186/80188.

When text editing is complete, programs can be developed as a single large module or divided into smaller modules. The linker combines smaller modules in a large module and, in the process, resolves external memory references, including the access and addition of specified library modules. The final load module becomes an absolute binary module for loading and executing in the target system with the support of the Kontron emulator.

The optional emulator provides the means by which designers can perform controlled tests. It has a connector to hook directly to the PC XT. When executed, software to control emulation automatically loads in the correct microprocessor support code.

The Kontron PC Interface is $1500. For further information, contact Kontron Electronics, 630 Price Ave., Redwood City, CA 94063, (415) 361-1012.

Circle 633 on inquiry card.

Fax Machine Wears Many Hats: Printer, Copier

A high-speed digital facsimile transceiver is available for $695, complete with a modem, from Image Communications. This fax machine can serve as a photocopier, computer printer, and optical scanner. It provides for simultaneous voice and data transmission on ordinary telephone lines.

This machine has a Z80A and interfaces that link with a computer through RS-232C or Centronics-type parallel ports. It can be used for scanning graphs and line drawings, which can then be transmitted through the interface ports to a computer for digitizing. An ASCII character generator or high-resolution dot graphics generator can be built in. It uses 8½-inch-wide roll paper.

For full details, contact Image Communications Inc., 511 Danbury Rd., New Milford, CT 06776, (203) 355-3747.

Circle 635 on inquiry card.

Microfloppy for Apple

The Shamrock Professional Utility Drive (SPUD) is a 3½-inch floppy-disk drive for the Apple II. It offers 328K bytes of formatted storage on 80 tracks. It plugs directly into the Apple's controller card and is built with analog read/write electronics that facilitate the interface.

Among its features are an optical sensor for track-zero positioning, a flashing LED that warns you when a disk is not write-protected, and a detachable shielded cable. The track-to-track access time is 6 milliseconds; the average access time is 158 milliseconds. The track density is 135 tracks per inch, and the data transfer rate is 250,000 bits per second.

SPUD is based on the Shugart SA-300 mechanism, which features a 300-rpm direct-drive motor, screw-thread read/write head positioning, and vertical clamping for proper media insertion.

The suggested retail price for SPUD is $600 (Canadian). For further details, contact Shamrock Computer Inc., 89 Telson Rd., Markham, Ontario L3R 1E4, Canada, (416) 474-0113.

Circle 636 on inquiry card.

PERIPHERALS

Four Modems, Telecomm Software from Racal-Vadic

Racal-Vadic, Milpitas, California, has entered the personal computer market with four modems and a telecommunications software package. The Maxwell Modem line, available in 300- and 1200-bps versions, comprises two add-in boards for the IBM PC and two desktop units that can be driven through an RS-232C port. Prices are $325 for the 300-bps IBM card, $595 for the 1200-bps IBM card, $350 for the 300-bps stand-alone unit, and $595 for the 1200-bps stand-alone. All prices include George, the telecommunications software package.

Although Racal-Vadic has established its own protocols for data transmission, its new line of modems conform to the AT&T 103 and 212 protocols and are compatible with virtually all other modems used on small computers. In addition, the 1200-bps units use Racal-Vadic's "coherent detection" techniques, which the company claims allow operation over telephone lines that other modems could not use. The modems will configure themselves automatically to the computers that are driving them, eliminating switch-setting problems during setup.

Other features of the modems include call-progress detection and reporting to inform the user if the line is busy, ringing, answered, or unanswered; automatic selection of pulse or tone dialing; and automatic detection and selection of Racal-Vadic or Hayes Microcomputer Products' software protocols.

George, the communications software, is available separately for $95. It has a text editor for writing or editing messages without leaving the program, single-keystroke auto-dial, several file-transfer methods including X-modem, unattended file transfer, and intelligent "close-enough name" access to the user-created dialing directory.

Contact Racal-Vadic, 1525 McCarthy Blvd., Milpitas, CA 95035, (408) 946-2227.
Circle **637** on inquiry card.

ROBOTICS

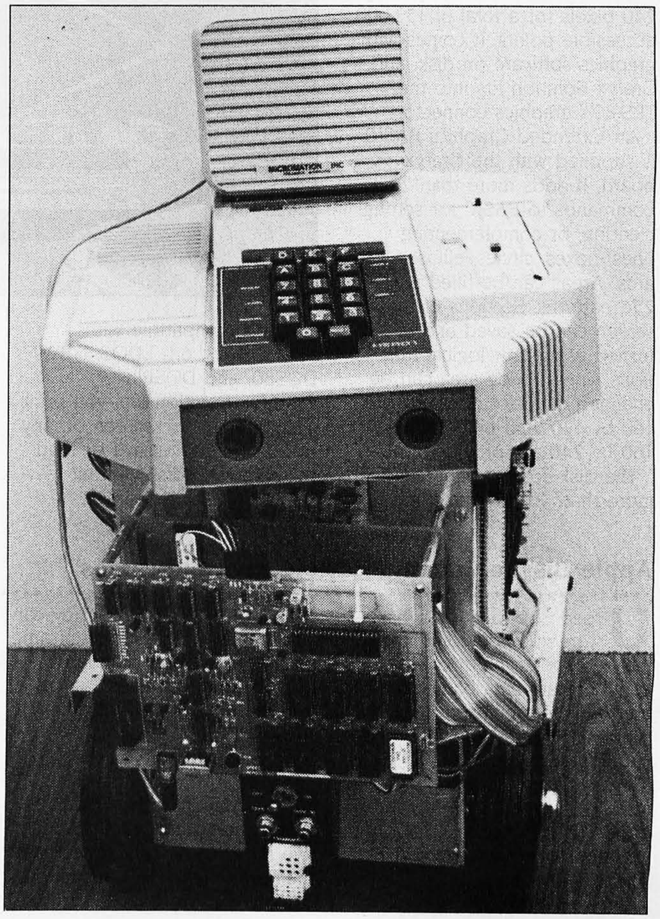
Voice-Command System for Hero

Micromation's VOREC voice-command system for Heath's Hero-I robot is a microprocessor-based speech-recognition board with a recognition accuracy of approximately 98 percent. Its speaker-dependent voice recognizer has a 256-word vocabulary of 16 word groups of 16 words each in 14K bytes of battery-backed static RAM.

VOREC uses high-speed CMOS chips and the 65C02 CMOS microprocessor to minimize battery consumption. Speech recognition is achieved by means of a software algorithm contained in a 2K-byte EPROM. An external speaker provides audio input, which is accurate up to 15 feet. The board is equipped with an RS-232C serial port for receiving and transmitting commands and data to the host robot.

A high-level software package, called Vocol, supplies immediate and deferred execution modes for the robot. Vocol has similarities to BASIC, except that it's speech dependent.

The Hero MEMCOM board, which lets you develop programs for the Hero, is required. The VOREC board costs $595. MEMCOM is available for $345. VOREC and MEMCOM together are $920. The source code is offered separately for $55. Contact Micromation Inc., 9104 Red Branch Rd., Columbia, MD 21045, (301) 730-1237.
Circle **638** on inquiry card.



Rangefinder Interface Priced Less Than $100

The Polaroid Rangefinder interface for the Hero-I robot is available for $89 from Interface Technology. The interface includes the Polaroid ultrasonic transducer, the Polaroid circuit board, and the interface in a plastic housing that mounts on the Heath robot.

Software for entering data, converting data to distance, and displaying data is supplied. The software can be used as a subroutine. All distance timing is performed in software. The range is 35 feet, with a resolution below a fraction of an inch (set by the software timing).

It comes fully assembled and tested. Contact Interface Technology Inc., POB 745, College Park, MD 20740, (301) 490-3608.
Circle **639** on inquiry card.

(continued)

ROBOTICS

Remote Operating System Provides Radio Link

Menos I is a hardware and software combination that lets you program Heath's Hero robot in conjunction with a personal computer. Hero and the computer communicate by an error-corrected two-way digital radio system, which provides both immediate execution and remote programming commands.

This system lets you write a program on your computer, download it to the robot, and communicate with the robot while the program is in progress. You can observe the motor positions and sensor readings while Hero is moving. In the software's simulation mode, you can watch on screen the results of what the robot will do at each step of the program. Programs can be written, simulated, and stored for later use.

Specifications for the remote computer include a 6801-type central processor, three support devices, 8K bytes of static RAM, 8K bytes of ROM, and an RS-232C port and/or radio link. Four expansion slots give you room for additional memory, interfaces, and library. RAM and ROM can be increased to up to 16K bytes.

Menos I comes with software on disk, a remote computer for the Hero, required hardware, and manual. With the radios, it's $795. With a cable link, the price is $595. Contact Virtual Devices Inc., Suite 104, 4801 Montgomery Lane, Bethesda, MD 20814, (800) 762-7626; in Maryland, (301) 986-1702.

Circle 640 on inquiry card.

ADD-INS

Grafyx Solution Works on Model 4

The Grafyx Solution board gives the Radio Shack TRS-80 Model 4 the ability to produce a resolution of 640 by 240 pixels for a total of 153,000 accessible points. It comes with graphics software on disk, and Grafyx Solution fits into the TRS-80's graphics connector.

An Extended Graphics BASIC is supplied with the Grafyx board. It adds more than 20 commands to BASIC for setting, clearing, or complementing lines, boxes, circles, ellipses, or arcs. Areas can be filled in with 256 patterns. Sections of the screen can be saved and returned using four logical functions. The viewing area can be changed, and dot densities of 160 by 120, and 640, 320, and 160 by 240 are provided.

The disk software contains more than 40 programs and files. It's compatible with TRSDOS 1.3, 6.1, LDOS, NEWDOS80, and DOSPlus.

Grafyx Solution lets you print a high-resolution screen on any of 20 printers or save or load the screen to disk without leaving BASIC. Labels can be printed in any direction.

The suggested retail price for Grafyx Solution is $199.95. A version for the Model III is available. Contact Micro-Labs Inc., 902 Pinecrest, Richardson, TX 75080, (214) 235-0915.

Circle 641 on inquiry card.

Apple Bisync Communications to Mainframes

Urgeo Software has a hardware/software combination that lets the Apple II or IIe communicate as a binary synchronous terminal with IBM mainframes and other bisynchronous devices.

Apple-Bisync allows the Apple to function as an IBM remote job-entry workstation. Files or job streams on an Apple disk can be transmitted directly into mainframe operations systems such as JES and RSCS. They can also be sent to other mainframe programs that use standard bisync protocols. Files can be received and stored on an Apple disk.

An editor helps you create and edit AppleDOS files. Files can be transmitted or received under the control of an executive file or proc, which permits multiple files to be transmitted or received on different drives.

Optional record compression, truncation, blocking, high-speed modems, and bisynchronous protocols allow data files to be exchanged between the Apple and mainframes reliably. Communications can be performed in an unattended mode.

The full Apple-Bisync system is $750. Contact Urgeo Software Inc., POB 305, Cheney, WA 99004, (509) 838-6058.

Circle 642 on inquiry card.

128K Memory Expanders for Color Computers

A line of 128K-byte memory expanders for the Radio Shack Color Computer is available. These expanders mount inside the computer and are compatible with existing software. They consist of two banks of 64K bytes that are selected by a three-position switch or through software. Each bank is independent, which allows separate programs to be loaded and run in either bank. When banks are switched, the unused bank is powered down, but all variables and vectors are preserved. Control can be passed from one bank to the other by moving two values into a memory location with a POKE statement. Variables can be transferred from one bank to another.

The expanders consist of a control circuit mounted in a module that plugs into the MC6821 PIA socket and the MC6883 SAM socket, two banks of 64K-byte RAM, and the toggle switch. The Model ME-128D for the earlier model D and E boards is $269. The ME-128F upgrade for the 285-type boards is $259, and the ME-128-64 for upgrading all 64K-byte Color Computers is $199. Contact Dynamic Electronics Inc., POB 896, Hartselle, AL 35640, (205) 773-2758.

Circle 643 on inquiry card.

ADD-INS

Phosphor Burn-in Protection

The Screen Boss is a circuit board that protects Apple II and II+ monitors from screen-phosphor burn-in, which results from prolonged display of a single image. It works by interrupting the video signal if the keyboard is not used for a user-adjustable period of time. Screen Boss connects easily and does not use an I/O slot. It costs $22.95, plus $2 postage. Contact CIRFAB Electronics, 558 Scarlett Rd., Toronto, Ontario M9P 2S2, Canada, (416) 248-0344.

Circle **644** on inquiry card.

80 Columns of Text on Apple IIe

The XB-7 80-column board for the Apple IIe computer is designed for use with Sakata's SC-200 RGB high-resolution color monitor. It's software-compatible with AppleDOS, Apple Writer IIe, Quick File IIe, Applesoft, Pascal, and CP/M. Text colors can be selected through switches; color selections are green, blue, amber, or white with highlighting always in white.

The XB-7 provides 16-color 40-column foreground and background text and 16-color low-resolution with optional mixing of 40-column foreground and background color text. In the medium-resolution (80 by 48) mode, it gives you the option of mixing 80-column switch-selectable color text. Other modes include high-resolution with 16 colors and 16-color 80 by 192 displays with the option of mixing 80-column switch-selectable color text.

The XB-7 comes with a manual, Apple IIe Rev B molex connector, and an RGB cable kit. The suggested price is $249. Contact Sakata U.S.A. Corp., 651 Bonnie Lane, Elk Grove Village, IL 60007.

*Circle **645** on inquiry card.*

8087 Chip Can Be Used in PCjr

TIAC has created a small circuit board adapter that lets you plug an 8087 microprocessor into the IBM PCjr. The jr-87 adapter is designed to plug directly into the 8088's socket, and the 8087 is then plugged into the adapter.

The TIAC board does not modify the PCjr, and it does not interfere with the operation of the PCjr's peripherals. The 8087 operates at the same speed on the PCjr as it does on the full-sized PC. Any software designed to run on 8087-based IBM PCs will run unmodified on the PCjr.

The price for this board is $89.95, without the 8087. For complete details, contact TIAC Manufacturing Inc., 3084 Spring St., Port Moody, British Columbia V3H 1Z8, Canada, (604) 461-1626.

Circle **646** on inquiry card.

Data-Communications Products from Anderson Jacobson

Anderson Jacobson has announced the availability of a pair of data-communications products: the PC Connection and the AJ 1212-AD2 auto-dial modem.

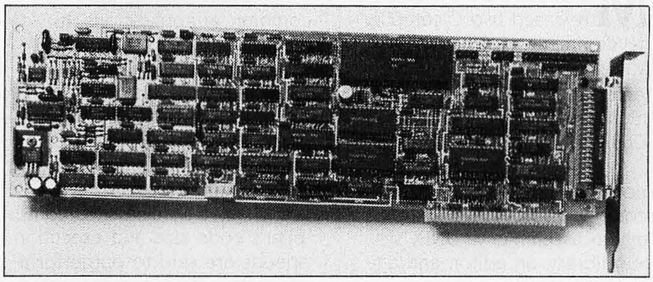
The PC Connection, a plug-in modem card for the IBM PC and PC XT, works with both AT&T 103 (0 to 300 bps) and AT&T 212 (1200 bps) protocols. It is fully compatible with Smartcom from Hayes Microcomputer Products and most major communications software. The PC Connection's setup is simplified by use of internal switches as well as software instructions. Simultaneous printing and communications are possible through use of two I/O ports. Additional features include a speaker to monitor calls in progress, a built-in asynchronous communications adapter, and selectable COM1:, COM2:, COM3:, or COM4: serial and modem port communications.

The AJ 1212-AD2 auto-dial modem offers computer log-on and two-level security with password protection. A multispeed asynchronous/synchronous modem compatible with AT&T 103 and 212 in a switched-telephone operation, the AJ 1212-AD2 can dial a computer upon receipt of a code name rather than a telephone number. A second-level password is required before allowing access to the modem's memory. Up to sixteen 37-digit numbers for automatic pulse- or Touch-Tone dialing can be stored in memory. A prefix of up to 19 digits can be added for speed-dialing to carrier networks. Comprehensive diagnostics are provided.

The PC Connection costs $495, and the AJ 1212-AD2 is $695. Contact Anderson Jacobson Inc., 521 Charcot Ave., San Jose, CA 95131, (408) 945-9030.

Circle **647** on inquiry card.

Hard-Disk Controllers with Encryption Option



SIGEN's DC-6 series of hard-disk controllers for the IBM Personal Computer provides error-correction techniques and backup and data-security options. The series can range as high as 16 heads and 200 megabytes of storage. It uses a proprietary "self-adjusting" technique that stores drive parameters and media information on "private" disk sectors so that once initially formatted, the drive can be used with any operating system.

The DC-6 series includes multiple-burst error correction, which is implemented through a combination of hardware and microcode. This arrangement enables error handling that's independent of the operating system.

An encryption/decryption facility is optionally available. The encryption option is based on the NBS Data Encryption Standard.

The Standard DC-6 hard-disk controller costs $395. With the encryption option, the price is $495. The DC-6 with a tape backup and the encryption option is $567. For further information, contact SIGEN Corp., Suite 7, 1800 Wyatt Dr., Santa Clara, CA 95054, (408) 988-2527.

Circle **648** on inquiry card.

(continued)

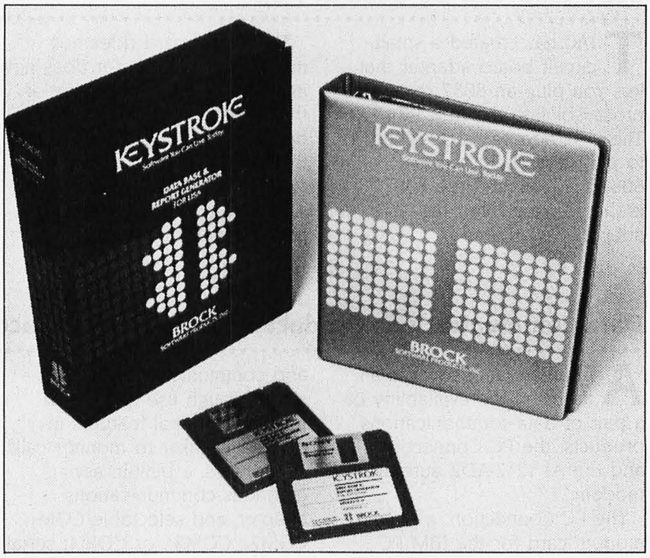
SOFTWARE•APPLE

Database Handles 2 Billion Records per File

The Keystroke Database for the Apple Lisa can handle 2 billion records per file. It lets you store, find, update, and print information rapidly and easily.

All references to storing and retrieving data are in English; common business terms are used throughout the program. A find/update function lets you locate and recall stored information by individual records, all records, or records with specific sets of conditions. Among the search formats are exact matching, greater and less than values, ranges, and such partial matching as "beginning with," "ending in," and "contains." Up to four search/sort fields can be defined within in a file.

As you design your files, Keystroke lets you specify computed fields that automatically do arithmetic calculations based on any available data within the file. A field-formatting capability lets you preformat types of data to be entered for consistent data presentations. A default response automatically enters constant data. A cross-reference feature can find and enter information from another file into your working file.



A report generator lets you translate input data into rows and columns. Reports can be sorted in up to 4 rows with 28 columns. Report features include boldface highlighting of user-defined conditions, summary-only reports, and statistical calculations in 10 columns with counts, averages, and totals.

Keystroke requires a 1-megabyte Lisa, a hard disk, and the Lisa Office System or Workshop. The suggested price is $595. Contact Brock Software Products Inc., POB 799, Crystal Lake, IL 60014, (815) 459-4210.

Circle **649** on inquiry card.

Macintosh C Development System

Manx Software Systems has released two C compiler development systems for the Macintosh: Aztec C68K-p and Aztec C68K-c. A set of development utilities, called the Aztec C68K Toolbox, is also available.

Aztec C68K-p, designed for personal use, comes with a C compiler, a 68000 relocating macro assembler, a UNIX system library, an editor, and a shell environment.

The C68K-c is intended for commercial applications. It comes with all the features of the personal version and with support for the Macintosh toolbox, including windows, an overlay linkage editor, and dynamically relocatable code with unlimited code size.

The Aztec Macintosh C compiler's code size and execution speeds are said to outperform any native development system currently available for the Macintosh.

The Aztec C compiler is also available as a cross-development system from PC-DOS, MS-DOS, CP/M-86, and Lisa. Prices begin at $199 for the personal C system. Contact Manx Software Systems Inc., POB 55, Shrewsbury, NJ 07701, (800) 221-0440; in New Jersey, (201) 780-4004.

Circle **650** on inquiry card.

MegaMerge Extends MacWrite

MegaMerge gives MacWrite mail-merge capabilities and unlimited document lengths. When used in conjunction with MacWrite, MegaMerge lets you produce form letters, mailing lists, and labels from a single master document and list. It gives you the ability to merge large blocks of information into printed documents, and you can link separate documents into a coherent whole.

MegaMerge sells for $125. Contact Megahaus Corp., 5703 Oberlin Dr., San Diego, CA 92121, (619) 450-1230.

Circle **651** on inquiry card.

Design Program for Apple Finds Use in Many Fields

You can create architectural designs, bar graphs, circuit and electrical diagrams, organizational and flow charts, floor plans, forms, office layouts, schematics, and project schedules with Quick-Draft, a computer-aided design program for the Apple II series.

Quick-Draft lets you use the Apple's keyboard, a joystick, or the KoalaPad to draw on the high-resolution screen. You can draw ellipses, circles, arrows, arcs, and polygons or use predefined shapes in any size, rotation, or color. You can fill closed areas with any one of 22 colors. Depending on memory, complicated designs can use 2 or 4 screens or up to 30 screens with additional memory.

Uppercase and lowercase text can be printed in 19 different fonts. A macro facility lets you define as many as 20 objects, each constituting multiple lines, figures, and text. These objects can be repositioned anywhere on screen and saved on disk. Hard-copy printouts of any screen or four contiguous screens can be obtained from a variety of dot-matrix printers.

Quick-Shape is a $25 option that helps you create custom shape tables of up to 127 members for use with Quick-Draft. It lets you edit shapes by enlarging any portion of the display screen from two to four times its normal size. Thirteen proportionally spaced text fonts and shape tables for mathematics, music, and electronics are provided.

RAM cards with 16K, 64K, and 128K bytes of memory are optional. On an AppleDOS 3.3-formatted disk, and with documentation, Quick-Draft is $50. For further information, contact Interactive Microware Inc., POB 139, State College, PA 16804-0139, (814) 238-8294.

Circle **652** on inquiry card.

SOFTWARE • IBM PC

OptionWare Runs Under Lotus

The DSS OptionWare line of application programs runs under Lotus 1-2-3 on the IBM Personal Computer. The DSS line comprises more than 55 programs and embraces such areas as financial statistics, sales, marketing, organization, budgeting, personnel management, sales aids, asset and cash management, personal management, and desktop organization.

Each application features menus and option lists, parameter setting screens, modifiable column and row headings section, calculation formulas, programming macros, summaries, and concise print formats. You can create comparative variance analyses, component analyses and subanalyses, and color or black-and-white graphs. Information can be swapped between OptionWare packages, and five main commands are consistent across all 56 applications.

OptionWare packages are priced at $130 each. Contact DSS Development Inc., Corporate Place, 4 Barnard Lane, Bloomfield, CT 06002, (203) 243-5554.

Circle **653** on inquiry card.

Freehand Color Art Program

The Vectrix Paint Program lets you draw freehand color graphics on your IBM PC or PC XT. A VX384A color graphics processor or the Vectrix Midas Color Card, a monitor, and the Summagraphics MM1200 series graphics tablet are required. With the VX384A, the Paint Program gives you a basic color palette of 16.8 million colors. Using the Midas Card, it provides a standard palette of 4096 colors. From either palette, you can work with 512 colors on any image.

Once you've selected your colors, the Paint Program offers you an icon menu of work options. Program features include air brushes, color mixing, 20 user-definable brushes, screen dump, disk storage, and rectangle filling. You can draw circles and horizontal and vertical lines and work with straight line, triangular, square, and circular brushes.

The Paint Program has a text submenu that contains both size and character modes. The size mode lets you pick a character size, and the character mode transfers control back to the PC's keyboard. Ten different fonts are provided, including script, italics, simple, duplex, and triplex.

The Paint Program for the Midas Card is $500; for the VX384A, it's $900. The manual alone is $45. The Midas Card is priced at $2995, while the VX384A is $4995. Contact Vectrix Corp., 2606 Branchwood Dr., Greensboro, NC 27408, (919) 288-0520.

Circle **654** on inquiry card.

Integrated Package Tailored for Executives

Micro Architect's IOAS-1 for the IBM PCjr is made up of two modules: Exec-I and Word-X. It requires 128K bytes of RAM and is priced at $99.

Exec-I is an executive information system consisting of seven applications: appointment, stock security, mailing list, checkbook, personal finance, personal inventory, and memo. The Word-X word processor has a full-screen editor, word wrap, and on-line help. It uses function keys and simple commands, and it can merge data files from Exec-I and produce form letters.

A version for the IBM PC XT is available; however, it requires an 80-column monitor. Contact Micro Architect Inc., 6 Great Pine Ave., Burlington, MA 01803, (617) 273-5658.

Circle **655** on inquiry card.

SOFTWARE • CP/M / MS-DOS

Modula-2 Compiler Runs Under CP/M-86K

Volition Systems released a Modula-2 compiler for the CP/M-68K operating system on September 1. The compiler is available for an introductory price of $495.

The Modula-2 compiler generates optimized machine code: one well-publicized benchmark executes in 1.74 seconds, which is said to be two to three times faster than other high-level languages on the 8-MHz 68000 microprocessor.

Volition Systems' Modula-2 compiler offers interrupt handling and the ability to produce ROM-based code. You can disable code optimization and execute programs without linking.

For full details, contact Volition Systems, POB 1236, Del Mar, CA 92014, (619) 481-2286.

Circle **656** on inquiry card.

LISP for CP/M

Computing Insights is marketing a version of LISP for Z80-based computers running CP/M 2.2. iLISP, founded on the LISP dialect called Scheme, features stack-free execution of "tail recursive" functions. It provides complete access to the CP/M file directory and sequential and byte-addressable random I/O to disk files.

iLISP has run-time LISP macro instructions and input-time READ macros. Both floating-point and integer arithmetic, including sine, cosine, arctan, and random, are standard. It gives you control over the executive, error-handling, and start-up functions. An assembly-language interface and trace and debugging utilities are provided.

Documented source code for all iLISP utilities is standard. Among those supplied are the LISP list editor, a print utility, and a function library system for maintaining random-access libraries of documented LISP code and values.

iLISP comes with a 165-page user manual and a 60-page introduction to iLISP programming. Formats available include 8- and 5¼-inch disks for Kaypro, Morrow, and Zenith computers. The suggested price is $49.95. For further information, write to Computing Insights, POB 4033, Madison, WI 53711.

Circle **657** on inquiry card.

IEP Structures Educational Programs for Disabled

The IEP Management System lets you structure a personalized individual education program (IEP) for a disabled child. It works on any microcomputer using CP/M and on Apple II+, Apple IIe, and Franklin computers.

Available options enable you to print out multiple IEPs and generate progress reports.

Foreign-language translations of reports or educational programs can be generated.

The IEP Management System is available on 8-inch single-sided, single-density CP/M disk formats and on 5¼-inch formats for the Radio Shack TRS-80 Model 4 and Zenith Z-89/Z-100 systems. It includes modifiable disk-data files, an operator's manual, and two training cassettes.

The basic IEP System, Level I, is priced at $3 per enrolled student (minimum $895). A 90-day license for the fully *operational* system, complete with options, is $50. For further details, contact Creative Educational Services, 36 River Ave., Monmouth Beach, NJ 07750, (201) 870-6543.

Circle **658** on inquiry card.

(continued)

SOFTWARE • TANDY / RADIO SHACK

Full-Screen Word Processor for Model III/4

The FullView word processor from Mitek Systems for the Radio Shack TRS-80 Model III or 4 is designed for large document preparation. Made up of separate text-editing and text-formatting programs, FullView features automatic section and subsection numbering, printer controls, and automatic generation of tables of contents, lists, figures, headers, and footers.

The full-screen text editor can load 6000 text characters in 3 seconds, scrolls at 50 lines per second, and permits cursor movement at up to 200 characters per second.

The FullView text formatter supports 65 directives that give you control over a document's specifications. It can format text at up to 100 pages per minute. It can handle impact and dot-matrix printers, as well as some of the new laser printers.

System requirements are 48K bytes of memory and a disk drive. Each program costs $49.50, which includes a manual and quick-reference card. Contact Mitek Systems Inc., 9580 Black Mountain Rd., San Diego, CA 92126.

Circle 659 on inquiry card.

Structured Programming Language

Allegro Software has introduced pC, a programming language and compiler for the Radio Shack TRS-80 Models I and III. The pC compiler translates source programs into Z80 instructions that can be executed directly on the TRS-80's Z80 processor, which is said to yield programs up to 50 percent faster than comparable BASIC programs.

pC uses structured programming techniques. It comes with a library of more than 60 functions, some of which permit access to the TRS-80's ROM and TRSDOS. Other functions support disk files, graphics, memory management, and strings. I/O files can be redirected when a pC program is running. You can create your own libraries. pC subroutines can be called from assembly-language subroutines and vice versa.

A 100-page manual, complete with a tutorial on structured programming, comes with pC. The full pC package is $99.95, which includes the compiler, a utility for merging library files, the run-time library, a utility library, and the source code for an arcade game. For further information, contact Allegro Software, POB 6593, Station J, Ottawa, Ontario K2A 3Y7, Canada.

Circle 660 on inquiry card.

+CODA+ Uses Stream-Cipher Encryption

A data security program, +CODA+ version 4.1 uses the stream-cipher technique, which combines text input with a stream of pseudorandom characters that are generated by the interaction of an internal key and an external, user-selected key. The internal key is specific to each +CODA+ program used; the external key consists of an 11-character keyword and a 2-digit page number. In a stream cipher, the corruption of a single character in an encrypted text results only in the corruption of that character and not in a block of text.

+CODA+ can be used with any type of data-storage or transmission system; no special error-checking precautions are required. It features a 48-character Teletype-compatible character set and a 10,000-member key library, which is accessible by library/page number.

A machine-code program and a BASIC program form the +CODA+ base. The machine-code program provides high speed and security for the encryption and decryption processes. It also contains the routines for subdividing encrypted data into five-character blocks, removal of spaces between words or blocks, keyword and page-number entry, and a number of other procedures. The BASIC program handles the I/O functions. An exit routine that wipes out both programs and a text buffer are included.

Available for the TRS-80 Models I and III, +CODA+ is normally supplied on a TRSDOS data disk. It requires 32K bytes and a disk drive. The list price is $100. Contact +CODA+ Data Security, 17 Douglas Ave., Newcastle upon Tyne, NE3 4XD, England; tel: 091 285 8667.

Circle 661 on inquiry card.

PUBLICATIONS

User-Supported PC Software

A directory of more than 100 public-domain and user-supported programs for the IBM PC can be purchased from the PC Software Interest Group. Listings include word processing, communications, database, DOS and BASIC utilities, games, graphics drawing utilities, turtle graphics, spreadsheet templates, RAM disks, and spoolers. Language programs include Pascal, C, assembly, and FORTH.

The programs are said to have been written by people who have opted not to market their work and who will allow others to copy it free of change. Authors of user-supported programs provide documentation and request a donation from satisfied users. Most of the public-domain programs come in source code.

The directory is $4.95, plus $1 postage and handling. A set of introductory disks can be obtained for $59. A complete set, comprising 135 disks, is $814. Contact PC Software Interest Group, Suite 130S, 1556 Halford Ave., Santa Clara, CA 95051, (408) 730-9291.

Circle 662 on inquiry card.

WHERE DO NEW PRODUCT ITEMS COME FROM?

The new products listed in this section of BYTE are culled from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers and distributors. The basic criteria for selection for publication are a) does a product match our readers' interests, and b) is it new or simply a "reintroduction" of an old item. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get more information. Send this to the New Products Editor, BYTE, POB 372, Hancock, NH 03449.

Books on Apple

A free catalog of computer books of interest to Apple users is available. Subjects include programming, games, self-help, writing BASIC programs, hardware and software sourcebooks, and graphics. Contact Sinequanon, POB 235, Cedarhurst, NY 11516.

Circle 663 on inquiry card.

CALL 1-800-222-2602

MONITORS

AMDEK COLOR I PLUS	309.95
AMDEK COLOR II PLUS	454.95
AMDEK COLOR IV	694.95
AMDEK VIDEO 300 (GREEN)	139.95
AMDEK VIDEO 300 (AMBER)	154.95
AMDEK VIDEO 310 (AMBER)	169.95
BMC 12" GREEN	89.95
BMC 13" COLOR	239.95
BMC 13" RGB	259.95
COMREX 13" COLOR W/SOUND	289.95
COMREX 12" HI-RES AMBER	119.95
COMREX 12" HI-RES GREEN	114.95
COMREX 13" RGB CR-6600	274.95
COMREX 13" RGB CR-6800	489.95
GORILLA 12" AMBER	84.95
GORILLA 12" GREEN	79.95
NEC 12" HI-RES GREEN	154.95
NEC 12" ECONO GREEN	109.95
NEC 12" LO-RES COLOR	294.95
NEC 12" AMBER SCREEN	159.95
NEC 12" COLOR - IBM	434.95
PRINCETON GRAPHICS HX-12	509.95
PRINCETON GR. 12" AMBER	189.95
SAKATA 13" COLOR	294.95
SAKATA 13" RGB COLOR	549.95
SAKATA SUPER RGB	749.95
SAKATA 12" GREEN	119.95
SANYO CTR-36 GREEN	169.95
TAXAN 12" GREEN	124.95
TAXAN 12" AMBER	134.95
TAXAN RGB 210 MED RES	309.95
TAXAN RGB 415 HI RES	439.95
TAXAN RGB 420 IBM	519.95
ZENITH 12" AMBER	109.95
ZENITH 12" GREEN	99.95
ZENITH RGB ZVM-135 COLOR	524.95
USI 9" AMBER PI-4	129.95
USI 9" GREEN PI-1	119.95
USI 12" AMBER PI-3	144.95
USI 12" GREEN PI-2	124.95
USI 13" LO-RES COLOR	309.95

MODEMS

ANCHOR MARK VII (RS-232)	119.95
ANCHOR MARK X (RS-232)	124.95
ANCHOR MARK XII (RS-232)	289.95
APPLE-CAT II MODEM	244.95
KENSINGTON MODEM 1200	429.95
NOVATION J-CAT	119.95
RIXON R212A 1200 BAUD	409.95
SMARTCAT 103/212	429.95
SMARTCAT 103	199.95
HAYES MICROMODEM IIe	234.95
SMARTMODEM 300 BAUD	219.95
SMARTMODEM 300 for //c	274.95
SMARTMODEM 1200 BAUD	484.95
SMARTMODEM 1200B - IBM	419.95
US ROBOTICS PASSWORD	379.95

DISKETTES

SS/SD ELEPHANT #1	16.95
SS/DD ELEPHANT #2	19.95
DS/DD ELEPHANT #5	25.95

PRINTERS

AMDEK 5040 40CPS DAISY	1439.95
ANADEX DP-9501B	1099.95
ANADEX DP-9625B	1299.95
ANADEX DP-9620B	1179.95
ANADEX WP-6000	2299.95
ANADEX DP-6500TR 500CPS	2529.95
ANADEX 9725B COLOR	1394.95
C.ITOH A10 DAISY WHEEL	509.95
C.ITOH 8510SP	489.95
C.ITOH 8600BP	799.95
C.ITOH 8510 SCP COLOR	569.95
COMREX CR-II DAISY WHEEL	499.95
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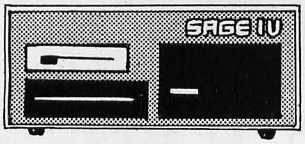

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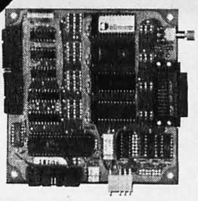

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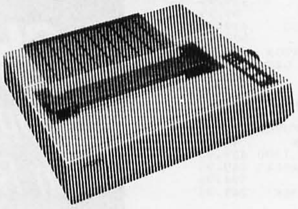

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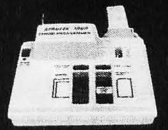

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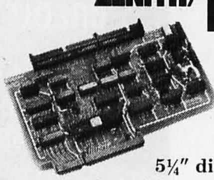

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PC **PORTABLE:** 256K, 2 drives	$2500
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#HO1	1 DRIVE, GREEN	$2135
#HO2	2 DRIVES, GREEN	$2625
#HO3	2 DRIVES, COLOR	$3235
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PC VIDEO-MONO	TSENG LABS ULTRAPAK
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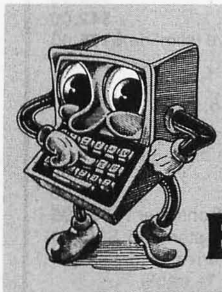

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QUBIE 1200B	PC iternal	$275
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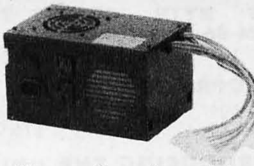

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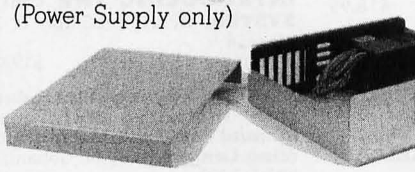

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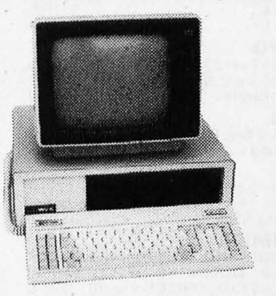

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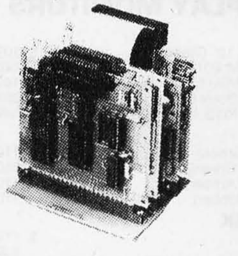

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- Cross assemblers for various computers.

BCC11 Assembled & Tested	**$149.** **New Low Price**

Z8 MEMORY. I/O EXPANSION. CASSETTE INTERFACE

- 8K bytes of additional RAM or EPROM.
- Three additional 8 bit parallel ports.
- Cassette interface—300 baud K.C. Standard.
- Software real time clock.

BCC03 w/4K RAM Assembled & Tested	**$150.**
BCC04 w/8K RAM Assembled & Tested	**180.**

Z8 EPROM PROGRAMMER

- Transfer BASIC or Assembly Language application programs from RAM to 2716 or 2732 EPROM.
- Comes with programming & utility routines on EPROM.
- Requires BCC03 Z8 Expansion Board for operation.

BCC07 Assembled & Tested	**$145.**

Z8 ANALOG TO DIGITAL CONVERTER

- Uses Analog Devices 7581 IC, 8-channel 8-bit.
- Adds process control capability to the Z8 system
- Over 1,000 conversions per channel per second.
- Monitors 8 analog signals in one of two 10v ranges.

BCC13 Assembled & Tested	**$140.**

Z8 SERIAL EXPANSION BOARD

- Adds additional RS-232C and opto-isolated 20 ma. current loop serial port to the Z8 System.
- Runs at 75 to 19,200 baud in all protocols.
- Comes with listings of sample serial I/O routines.

BCC08 Assembled & Tested	**$160.**

Z8 16K MEMORY EXPANSION BOARD

- Add up to 16K of additional memory, RAM or EPROM, to your Z8 System Controller in any multiple.
- Accepts 2016, 6116, 2716, or 2732 memory types.
- Four 16K cards may be installed on the Z8 System bringing the total memory to 64K.

BCC14 Assembled & Tested w/8K RAM	**$120.**
BCC16 Assembled & Tested w/16K RAM	**155.**

COMING SOON! FORTH LANGUAGE VERSION OF THE Z8

With the new Z8 with on board 4K FORTH you can program high speed control functions in a few simple high level language commands. Perfect for data reduction, process control and high speed control applications.

BCC20 Z8F FORTH Microprocessor chip	**$150.**
BCC21 Z8F FORTH System Controller (This board is a BCC11 with a BCC20 installed) Assembled & Tested	**280.**

Z8 CROSS ASSEMBLERS

From Micro Resources

IBM PC, APPLE, 6502 Systems 5¼", CP/M 2.2 8"	**$ 75.**

From Allen Ashley

TRS-80 Model I, III, Northstar 5¼"	**75.**
CP/M 2.2 8"	**150.**

Z8 FIVE SLOT MOTHER BOARD

- Expand your Z8 BASIC System with minimum effort.
- Contains five slots complete w/44 pin connectors.

MB02 Assembled & Tested	**$69.**

TRIPLE VOLTAGE POWER SUPPLIES

+5V @ 300 ma. + / − 12V @ 25 ma.

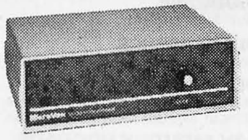
UPS01 Assembled & Tested	**$35.**
UPS02 Complete Kit	**27.**

+5V @ 1 Amp. +12V @ .5 Amp. −12V @ 50 ma.

UPS03 Assembled & Tested	**60.**
UPS04 Complete Kit	**50.**

SPEECH SYNTHESIZERS

MICROVOX TEXT-TO-SPEECH SYNTHESIZER



As featured in Ciarcia's Circuit Cellar
BYTE Magazine September, October 1982.

Microvox is a second generation professional voice quality text-to-speech synthesizer that is easily interfaced to any computer, modem, RS-232C serial or parallel output device and provides speech of unbelievable clarity.

- Unlimited vocabulary.
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- 6K text-to-speech algorithm.
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- X-On/X-Off handshaking.

MV01 Assembled with 1K buffer	**$299.**
MV02 Complete Kit with 1K buffer	**219.**

Add $15.00 for 3K buffer option.

VOTRAX SC-01A PHONETIC SPEECH SYNTHESIZER IC

The SC-01A Speech Synthesizer is a completely self-contained solid state device that phonetically synthesizes continuous speech of unlimited vocabulary. Used in our Microvox and Sweet-Talker.

SC01A Quantity 1–99	***$44. ea.***
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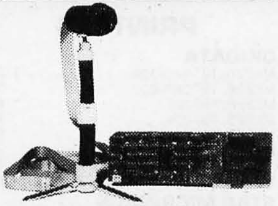

As featured in Ciarcia's Circuit Cellar
BYTE Magazine, September & October 1983

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- 256 × 128 digital image sensor.
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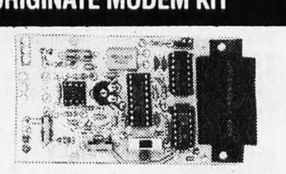
- Software includes utilities for auto exposure, multi-level greyscale, screen dump and image enhancement.
- Includes interface card, 4 foot extension cable, camera assembly, manual, and software on diskette.

DC01 IBM PC Assembled & Tested	**$299.**
DC02 IBM PC Complete Kit	**264.**
DC03 APPLE II Assembled & Tested	**299.**
DC04 APPLE II Complete Kit	**264.**

300 BAUD ANSWER/ ORIGINATE MODEM KIT



As featured in Ciarcia's Circuit Cellar
BYTE Magazine, March 1983

Micromint's latest 300 Baud Modem Kit is crystal controlled, uses the TI TMS99532 IC, contains just 25 parts and requires no calibration or adjustments. Use with acoustic coupler or in direct connect mode.

MD04 Complete Kit as shown	**$60.**
MD05 Transformer for Direct Connect Mode	**9.**
AC01 Acoustic Coupler Kit	**20.**

E-Z COLOR GRAPHIC INTERFACE WITH SPRITES

APPLE II E-Z Color plug-in board with Graphics Editor on 3.3 disk

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EZ02 Complete Kit	**125.**

APPLE II E-Z Color Plus

- Allows the use of a single monitor or TV set.

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- Animate Sprites from your own BASIC program.

EZ21 Animation Software	**$49.**

S100 E-Z Color Graphics Board

- With sound generator & joystick interface.
- MBASIC Graphics Editor on 8" diskette.

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Part No.		DXXP	DXXS	RDXXP	RDXXS	DXXCGY	DXXC
Contacts	9	2.05	2.65	3.90	3.20	1.55	----
	15	2.05	3.60	3.70	5.40	1.55	----
	25	2.50	3.25	4.50	4.80	1.55	1.25
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8 PIN LP	.12	.10
14 PIN LP	.14	.12
16 PIN LP	.16	.14
18 PIN LP	.18	.16
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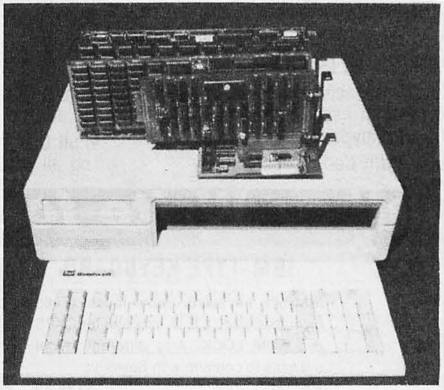

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MOTHER BOARD:

- 8088 CPU with socket for co-processor 8087
- 8088 is supported by 8259A interrupt controller and 8237 DMA controller
- 2 (two) 28 pin sockets for ROM
- 8 (eight) expansion slots
- No RAM on board (RAM is on multifunction board)

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(With IC sockets, resistors, capacitors, connectors, crystals, transistors soldered)
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IC kit **199.00**

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Standard Features:

- PC-DOS™ Operating System Vers. 2.1
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- 5 IBM compatible expansion slots
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- Power Supply is Hard Disk ready, no need to add-on additional power
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If that incredibly *LOW* Total System price doesn't suit you, try this ***"Do it Yourself System"*** and take your pick of the wide range of options listed below.

The Features: •64K RAM •Expandable to 256K
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•2 Serial and one Parallel Port
•and MORE! •SYS-8000-00

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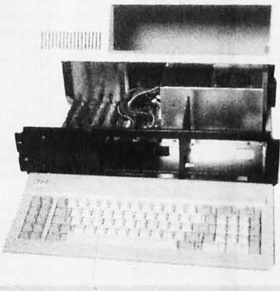

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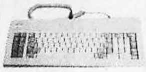
IBM-TYPE KEYBOARD



IBM-type keyboard. Super touch! (Even nicer than IBM!) L.E.D. indicator for CAPS and NUM LOCK. Also different layout available to conform with Selectric.

KEY-1000-00 . . . . **$139.00**
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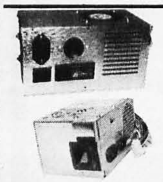

Linear Power Supply with fan and power filter. Fits in case above. Uses 140 watts and runs Hard Disk. Mounting hardware and power cord included.

POW-1030-00 . . . . **$175.00**

Also IBM replacement type for Hard Disk.

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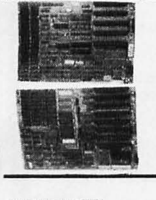

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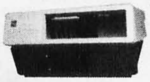

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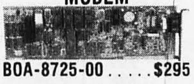

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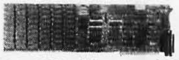

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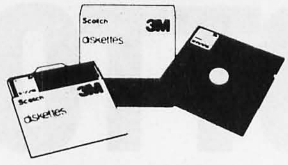

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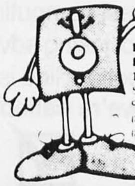

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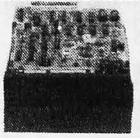

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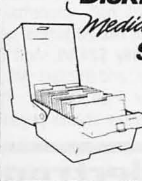

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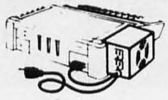

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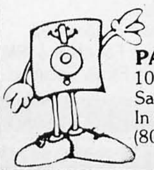

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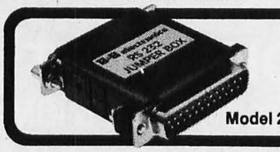

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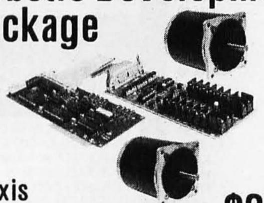

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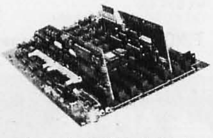

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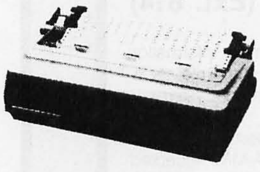

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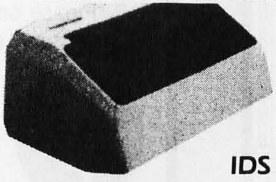

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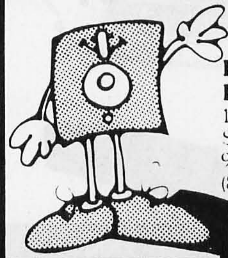

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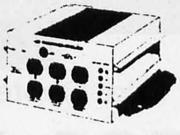

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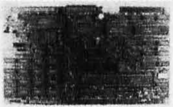

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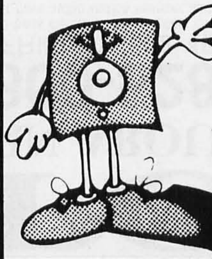

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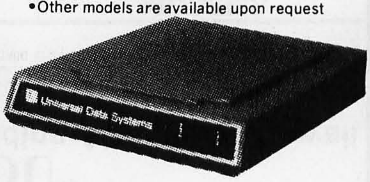

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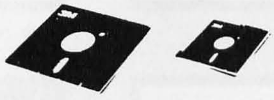

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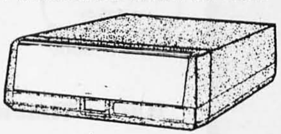

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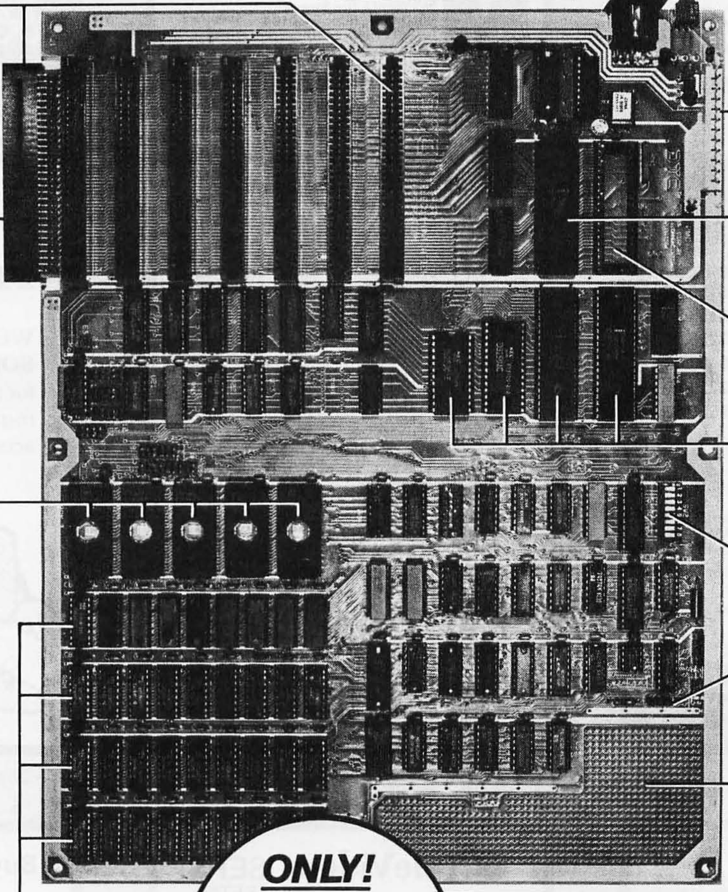

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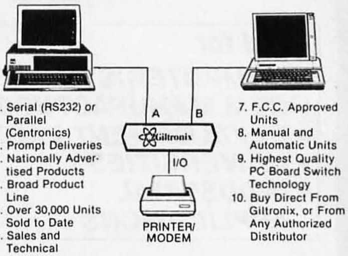

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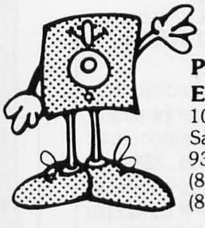

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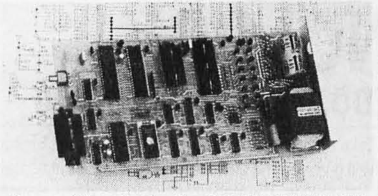

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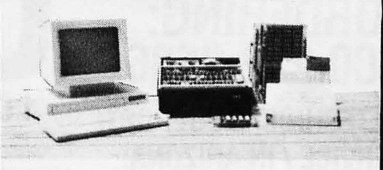

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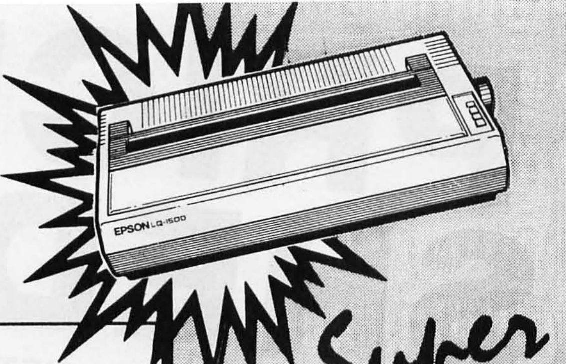

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24 pin head, 200 CPS draft mode, 67 CPS letter quality mode

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TRACTOR	*89*	54.95
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EPSON RX-80 100 CPS w/tractor, graphics	CALL FOR BEST PRICE
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OKI 92 parallel	*599*	409.95*
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IBM PC ROMS for 92	*59*	49.95
IBM PC ROMS for 93	*69*	59.95
Extra 82/93 Ribbons (2)	*19*	9.95
82/92 tractor	*89*	54.95
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OKI 82 *120 CPS*	*499*	299.95
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OKI 84 parallel *200 CPS*	*1395*	849.95*
OKI 84 serial *200 CPS*	*1495*	999.95
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IBM PC ROMS for 84	*99*	89.95
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OKI 2350 parallel	*2695*	1899.95
OKI 2350 serial	*2775*	1999.95

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Allows your computer to run either of two printers. Standard parallel switch box

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Starwriter F-10 *55 CPS*	*1995*	1299.95
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Comrex CR-II *5K parallel*	*599*	489.95
Comrex CR-II *5K serial*	*644*	589.95
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Keyboard for CR-II	*199*	179.95
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Tractor for 500	*149*	124.95
Silver Reed 550 *18 CPS*	*699*	599.95
Tractor for 500	*159*	129.95
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Tractor for 770	*159*	139.95
Juki 6100 *18 CPS*	*599*	449.95
Tractor for 6100	*149*	124.95
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High speed & letter quality!

High quality 24 pin head, 192 CPS draft mode, 96 CPS letter quality

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	LIST	JADE
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32K	*260*	199.95
Parallel in/Serial out		
8K	*199*	169.95
32K	*260*	199.95
Serial in/Serial out		
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32K	*260*	199.95

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64K add-on board	*179*	149.00
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Serial, 16K	*259*	189.95
Serial, 32K	*299*	229.95
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Plug-n-Run, ready to go, complete with controller card, data cable, and mounting hardware, totally PC/XT compatible, faster than XT, handles 4 different operating systems, streamer tape back-up available. External model includes cabinet & power supply

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	LIST	JADE
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AMDEK 310A	230	169.95
AMDEK 300A	199	149.95
AMDEK COLOR I	379	279.95
AMDEK COLOR II	559	419.95
AMDEK COLOR IV	995	649.95
PGS MAX-12	269	199.95
PGS HX-12	699	469.95
PGS SR-12	799	649.95
QUADCHROME	795	499.95
COMREX CR6800	649	499.95

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	LIST	JADE
KEYTRONICS KEYBOARD	209	149.95

HIGH SPEED 8087 APU

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	LIST	JADE
RIO PLUS 64K	395	329.95
RIO PLUS 128K	495	349.95
RIO PLUS 256K	595	449.95
RIO PLUS 384K	795	549.95
SUPER RIO 64K	419	329.95
SUPER RIO 128K	519	379.95
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320K DISK DRIVES For IBM PC

Double-sided, double-density

TANDON 100-2 Two for 175.00 each
TEAC 55B Two for 149.00 each
FOR JUST ONE DRIVE ADD 4.95

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MULTIPLAN	250	169.95
ACCOUNTING PARTNER	395	249.95
CROSSTALK	195	129.95
PROKEY	75	54.95
MULTIMATE	495	299.95
SUPERCALC III	395	249.95
TRANSEND PC	189	139.95

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	LIST	JADE
MOUSE w/WORD	495	339.95
MOUSE	199	129.95
SYSTEM CARD 64K	395	279.95
SYSTEM CARD 256K	625	429.95

LOCAL AREA NETWORKS For IBM PC

	LIST	JADE
QUADNET II	995	879.95
QUADNET VI	1995	1659.95
QUADNET IV	2295	1989.95
AST-PC net II	495	399.95
ORCHID TECHNOLOGY	595	499.95

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High quality double-sided, double-density diskettes, certified to be absolutely error free. Box of 10, warranteed for one year

	LIST	JADE
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MEGA PLUS 64K	395	269.95
MEGA PLUS 256K	665	429.95
MEGA PLUS 512K	1095	799.95
I/O PLUS	165	119.95
MP PLUS 64K	295	199.95
MP PLUS 128K	395	249.95
MP PLUS 192K	495	299.95
MP PLUS 256K	595	349.95
MP II 64K	345	249.95
MP II 128K	445	299.95
MP II 192K	545	349.95
MP II 256K	645	399.95
MP II 384K	845	499.95

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	LIST	JADE
HERCULES COLOR	245	189.95
HERCULES GRAPHIC	499	339.95
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QUADCOLOR I	295	209.95
QUADCOLOR II	275	209.95
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High speed RAM upgrade kit with FREE! parity (error detection) and one year warranty

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192 KIT For IBM PC	270	131.95
256K KIT For IBM PC	360	173.95
384K KIT For IBM PC	540	259.95

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QUADBOARD 64K	395	275.95
QUADBOARD 128K	495	339.95
QUADBOARD 256K	595	339.95
QUADBOARD 384K	795	595.95
QUADLINK	680	449.95
QUAD 512 PLUS 64K	325	239.95
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QUAD 512 PLUS 512K	895	549.95
QUADCOLOR I	295	209.95
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Smartmodem 300	*289*	**199.00**
Hayes Cronograph	*249*	**199.95**
Micromodem 100	*399*	**299.95**
Micromodem IIe	*299*	**239.95**
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Smartcom II	*149*	**99.95**

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1/5 the size of ordinary modems, Bell 103, manual or, auto-answer. Automatic answer/originate, direct connect, built-in self-test, two LEDs and audio beeps provide status information

	LIST	JADE
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with FREE! SOFTWARE

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SHUGART SA-851R DS/DD
List 605 ______ **459.00 ea** 2 for **455.00 ea**

TANDON TM 848-2 DS/DD thin-line
List 599 ______ **439.00 ea** 2 for **435.00 ea**

NEC FD1165 DS/DD thin-line
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A & T w/2 Siemens FD100-8Ds	*995*	**529.00**
Kit w/2 Shugart SA-801Rs	*1195*	**939.00**
A & T w/2 Shugart SA-801Rs	*1295*	**969.00**

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Kit w/2 Shugart SA-851Rs	*1495*	**1199.00**
A & T w/2 Shugart SA-851Rs	*1595*	**1219.00**

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A & T w/o drives	*249*	**164.95**
A & T w/2 DS/DD drives	*1495*	**1099.00**

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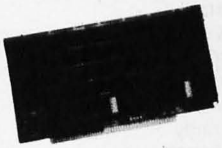
S-100 64K "CMOS" RAMCARD



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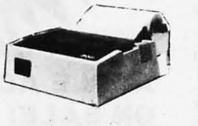

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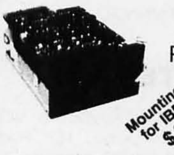

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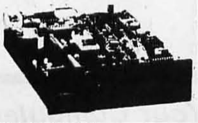

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MPI B52	239.00	SEAGATE ST506 (6MB Win.)	349.00

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Set of 9 $50.00

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HARCOURT Computer SAT	Call
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INFOCOM Zork I, II or III	29.00
Deadline	36.00
KOALA Modules (8 available)	Call
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Juggles Rainbow	30.00
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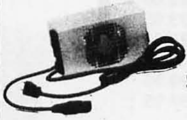

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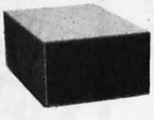

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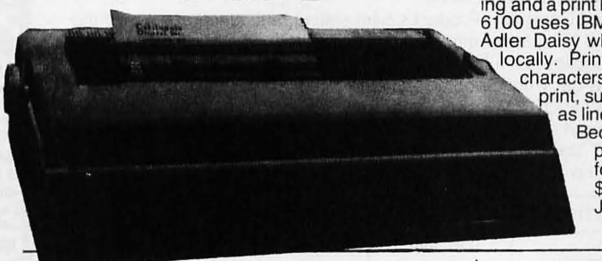

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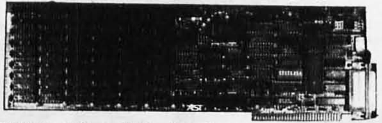

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FIVE INCH SINGLE SIDED DOUBLE DENSITY

	Soft Sector Ten Sector Sixteen	Each box	10 Boxes	100 Boxes
CAL DIGITAL	CAL-501 CAL-510 CAL-516	18.95	17.50	16.50
SCOTCH	MMM-744/0 MMM-744/10 MMM-744/16	24.95	22.75	21.75
VERBATIM	VRB-525/01 VRB-525/10 VRB-525/16	24.95	22.75	21.75
MEMOREX	MRX-3481 MRX-3483 MRX-3485	24.95	21.75	17.75
MAXELL	MXL-MD1 MXL-MH1/10 MXL-MH1/16	24.95	22.75	21.25
DYSAN	DYS-104/1D DYS-107/1D DYS-105/1D	35.00	33.00	30.50

FIVE INCH DOUBLE SIDED DOUBLE DENSITY

CAL DIGITAL	CAL-551 CAL-561 N/A	24.95	22.75	20.50
SCOTCH	MMM-745/0 MMM-745/10 MMM-745/16	37.95	35.95	31.25
VERBATIM	VRB-550/01 VRB-550/10 VRB-550/16	37.95	35.95	32.75
MEMOREX	MRX-3491 MRX-3493 MRX-3495	32.95	31.25	26.25
MAXELL	MXL-MD2 MXL-MD2/10 MXL-MD2/16	37.95	35.95	33.75
MAXELL / 96	MXL-MD2/96 N/A N/A	45.00	43.00	41.25
DYSAN	DYS-104/2D DYS-107/2D DYS-105/2D	42.50	40.50	35.50
DYSAN / 96	DYS-204/2D N/A N/A	49.95	47.95	45.75

EIGHT INCH SINGLE SIDED SINGLE DENSITY

SCOTCH	MMM-740/0	28.50	27.50	23.80
MEMOREX	MRX-3062	27.75	26.60	22.25
VERBATIM	VRB-34/9000	31.50	29.50	25.60
DYSAN	DYS-3740/1	35.75	32.75	29.75

EIGHT INCH SINGLE SIDED DOUBLE DENSITY

SCOTCH	MMM-741/0	33.95	31.75	29.15
MEMOREX	MRX-3090	31.95	27.75	26.15
VERBATIM	VRB-34/8000	35.25	33.25	28.75
DYSAN	DYS-3740/1D	40.75	38.75	32.25
MAXELL	MXL-FD1	45.50	39.75	35.15

EIGHT INCH DOUBLE SIDED DOUBLE DENSITY

SCOTCH	MMM-743/0	45.95	43.25	37.50
MEMOREX	MRX-3102	37.95	36.75	31.50
VERBATIM	VRB-34/4001	41.75	37.50	32.25
DYSAN	DYS-3740/2D	54.65	49.75	40.50
MAXELL	MXL-FD2	52.50	48.75	40.45

$49 Apple Macintosh Diskettes

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NEC RGB COLOR MONITOR $259

The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White. These monitors are currently being used in applications far more critical than microcomputers.

The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these prime "new" RGB monitors at a fraction of their original cost. Sanyo compatible NEC-1401/S; IBM/P/C Computer compatible NEC-1401/PC

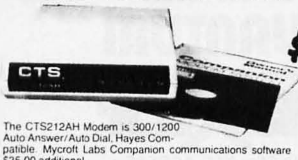
MONITORS

BMC 12A green phosphor 15 MHz. composit video.	BMC-12A	78.95
BMC 12" high resolution, 20MHz.	BMC-12EN	119.00
Amdek 300G 12" green phosphor	AMK-300G	128.95
Amdek 300A 12" amber phos., hi-resolution	AMK-300A	138.95
Amdek 310A designed for IBM/PC, amber	AMK-310A	158.95
Zenith ZVM122 Amber Phosphor 12" 40/80 column switch	ZTH-122	94.95
Zenith ZVM123 green phosphor 12" 40/80 column switch.	ZTH-Z123	94.95
NEC JB1201 green phosphor 18 MHz. composit video.	NEC-JB1201	159.00
NEC JB1260 commercial grade composit	NEC-JB1260	119.00
Motorola 23" open frame blk/white composit video.	MOT-BW23	159.00
Conrac 9" open frame requires horz sync. & 12v. supply.	CON-BW9	59.00

COLOR

NEC JC1401D Medium/High 13" RGB	NEC-1401/X	259.00
BMC AU9191U Color composit video with sound	BMC-9191	238.95
BMC 9191M RGB designed for use with the IBM computer.	BMC-9191M	379.00
NEC JC1203DM, RGB color monitor	NEC-1203	699.00
NEC JC1201 color composit.	NEC-JC1201	339.00
Zenith ZVM135 RGB & composite suitable for IBM PC	ZTH-Z135	475.00
Amdek Color I, 13" composit video	AMK-100	299.00
Amdek Color II+, 13" RGB hi/resolution	AMK-200	419.95
Amdek Color III+, 13" RGB, medium resolutiion	AMK-300	359.95
Princeton HX-12 RGB IBM/PC compatible	PRN-HX12	478.95

MODEMS



$319

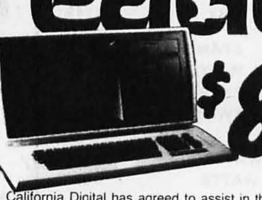
The CTS212AH Modem is 300/1200 Auto Answer/Auto Dial, Hayes Compatible. Mycroft Labs Companion communications software $35.00 additional.

CTS 212AH 1200 baud, auto dial	CTS-212AH	319.00
Signalman Mark 12, 1200 baud, Hayes compatible.	SGL-MK12	259.00
Signalman Mark 1, direct connect with terminal cable.	SGL-MK1	75.00
Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	479.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	429.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
U.S. Robotics 212A 300/1200 baud, auto dial/answer.	USR-212A	439.00
U.S. Robotics Password 300/1200 baud	USR-PW212	389.00
Penril 300/1200 industrial quality	PEN-12AD	595.00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169.00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	219.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	359.00
Novation 'J' Cat, direct connect, auto answer	NOV-JCAT	115.00
Novation SmartCat 103/212, 1200 baud auto dial	NOV-SC212	529.00

$389 TANDON 603SE

These Tandon 14.2 Megabyte hard disk drives are the excess inventory of a major computer company. Each unit has passed 24 hours of incoming burn-in.

EAGLE $895

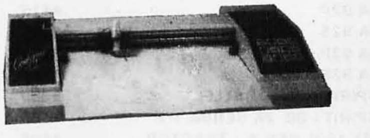


California Digital has agreed to assist in the liquidation of approximately 1000 Eagle IIE/2 Computers.

These units features a 12" non-glare green phosphor CRT, typewriter style keyboard with separate numeric cluster. This unit provides two 5 1/4" drives for a combined storage capacity of 780 K/Byte. The Eagle II contains a 4Mhz Z-80A, DMA disk interface, two RS-232C serial ports, Centronics printer interface, along with an auxillary parallel port. Software included consists of ULTRACALC electronic spread sheet, SPELLBINDER word processor, CBASIC2, CP/M 2.2, and an exclusive Eagle menu driven utility package.

These units are all "factory new" and are being offered far below their suggested price of $1995. This is your opportunity to purchase a complete CP/M system for only $895. EAG-2E2

Epson Comrex PLOTTER $189



The Comrex Comscriber I is the ideal solution to make short work of translating financial and other numeric data into a graphic presentation. Complete with menu driven software for use with either IBM/PC or Apple II. Along with this are included multicolor plotter pens, demonstration software

The Comscriber I was originally priced to sell at $795. This is your opportunity to purchase a high value graphic plotter at only $189. IBM/PC COM-C1PC; Apple COM-C1A2

PRINTERS

MATRIX PRINTERS

Star Gemini-10X 120 char/sec.	STR-G10X	279.00
Star Gemini-15X, 100 char./sec. 15" paper.	STR-G15X	389.00
Star Gemini Delta 10, 160 Char/sec	STR-D10	399.00
Star Coex 80FT friction & tractor	VST-C80FT	195.00
Toshiba P1351, 192 char/sec. letter quality	TOS-1351	1495.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	347.00
Okidata 92A parallel interface, 160 char/sec	OKI-92A	427.00
Okidata 83A & parallel 15" paper	OKI-83A	567.00
Okidata 84A & parallel 15" paper	OKI-84A	997.00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson RX-8010" 120 Char/sec.	EPS-RX80	317.00
Epson FX80, 10" 160 char./sec. with graphtrax	EPS-FX80	529.00
Epson FX 100 15" 160 char./sec with graphtrax	EPS-FX100	719.00
Anadex 9501B high speed with graphics	ADX-9501B	1029.00
Anadex 9620B 200 char/sec. par'l & serial.	ADX-9620B	1129.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	359.00
Prowriter II, parallel 15" paper, graphics	PRO-2P	689.00
Dataproducts B-600-3, band printer 600 LPM.	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines per minute.	PTX-P600	5795.00

WORD PROCESSING PRINTERS

NEC7710 55 char/second, serial interface	NEC-7710	1795.00
NEC7730 55 char/sec, par'l interface.	NEC-7730	1795.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1599.00
NEC2050 designed for IBM/PC 20 char/sec. par'l	NEC-2050	995.00
Silver Reed EXP500, 14 char/sec. par'l interface	SRD-EXP500	459.00
Silver Reed EXP550 17 Char/sec par'l interface.	SRD-EXP550	659.00
Diablo 630 40 char/sec. serial	DBL-630	1765.00
Diablo 620, proportional spacing, horz.& vert. tab. 20 cps.	DBL-620	879.00
Juki 6100, 18 char./sec. SPECIAL	JUK-S6100	319.00
Brother HR1A serial interface	BTH-HR1S	695.00
Starwriter F10 serial, 40 char/sec.	PRO-F10S	1125.00
Starwriter F10 parallel, 40 char/sec.	PRO-F10P	1125.00
Comrex CR2, 5k buffer, proportional spacing, par'l.	CRX-CR2P	495.00

TERMINALS

Freedom 100, split screen, detatchable keyboard	LIB-F100	495.00
Qume 102 green phosphor terminal	QUM-102	539.00
Ampex Dialogue 125 green screen,	APX-D125G	675.00
Ampex Dialouge 175 amber screen, two page, func. keys	APX-D175A	719.00
Wyse 50, 14" green phosphor	WYS-50	595.00
Wyse 300, Eight color display, split screen.	WYS-300	1159.00
Zenith 29 terminal, VT52 compatible. detatch.ble keyboard.	ZTH-Z29	765.00
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950, graphic char.,split screen, 22 func.	TVI-950	950.00
Televideo 970, 14" green, 132 column, European	TVI-970	1095.00

Return of a Smash Hit Sellout

DRAGON $139

Compatible with the Radio Shack Color Computer. The world famous Dragon computer is now available in the United States. Manufactured by the Tano Corporation under license of the British Broadcasting Company. The Dragon comes complete with 64K Byte of memory, serial modem port along with a Centronics printer interface. This unique microcomputer features Motorola's advanced 6809E microprocessor and comes standard with Microsoft Color Basic, data base manager, and a complete word processing package. The computer outputs color composite video along with R.F. video that allows the unit to be used in conjunction with any color television. This is the Ideal low cost computer to be used with any dial up information system such as the Source, Western Union's EasyLink or any other time share service.

California Digital has agreed to act as exclusive agent for North America in an effort to assist The Tano Corporation in reducing their overstock. For a limited time California Digital can offer the Dragon computer for only $139.

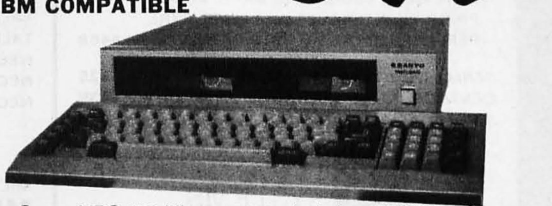
FREE

Your Choice

Second Drive or Monitor

SANYO $895

IBM COMPATIBLE



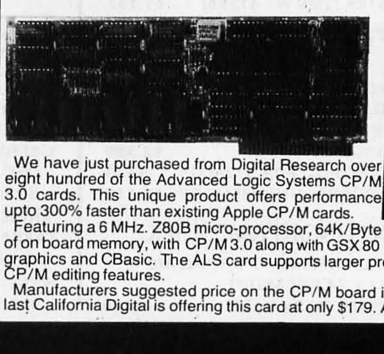
The Sanyo MBC-550 Microcomputer includes 128K byte of memory, a 5¼" disk drive along with a parallel printer port. The computer outputs both RGB color and monochrome composite video. Extensive software such as Sanyo Basic, Wordstar, Calcstar and Easy Writer I is included with the MBC-550.

Along with this all this California Digital offers "FREE" your choice of either a second disk drive, or a high resolution green or amber screen monitor. All at the super low price of only $895.

Double sided 320K/byte disks drives are available at only $99 per drive additional.

Advanced Logic Systems CP/M 3.0 CARD $179

Includes Digital Research C/PM Plus



We have just purchased from Digital Research over eight hundred of the Advanced Logic Systems CP/M 3.0 cards. This unique product offers performance upto 300% faster than existing Apple CP/M cards.

Featuring a 6 MHz. Z80B micro-processor, 64K/Byte of on board memory, with CP/M 3.0 along with GSX 80 graphics and CBasic. The ALS card supports larger programs with enhanced CP/M editing features.

Manufacturers suggested price on the CP/M board is $399. while supplies last California Digital is offering this card at only $179. ALS-Z80

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SUPER SIX 128-6MHz	$595
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SUPER 186/256-SLAVE	$1,450
CP/M 3.0	$350
TURBODOS MULTI-USER	$650
HDC-100-5 5¼" H.D. CONTROLLER W/ S.W. DRIVES	$450
SUPER STAR SYSTEM: SUPER SIX 128K, 5Mb FIXED, 5Mb REMOV. CART., DSDD FLPY, 2 SUPER SLV-128-6, *TURBODOS 1.3 MULTI-USER*	$4,949

INTERCONTINENTAL MICRO SYSTEMS CORPORATION

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CPS-BMX 128K RAM SLAVE 6MHz	$529

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512K PIGGY-BACK EXPANSION	$695
BATTERY BACK-UP W/PWR. SUPPLY	$169
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CENTRONICS PARA OPTION FOR MFIO	$39
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VERSAFLOPPY II 4 FLPY CTRL 5¼" & 8"	$295
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EXPANDORAM IV 256K W/ EDC	$1,435
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Cromemco

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EXC S-100 EXTENDER BD.	$49
SMDI SMD HARD DISK I/O	$675
DPU 68000 & Z80A	$669
FFP FAST FLOATING POINT	$2,369
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XT-1105 105.27Mb 30m SEC ACCESS	$2,995
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5V = Single 5 Volt Supply

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1702	256 x 8 (1us)	4.45
2708	1024 x 8 (450ns)	2.49
2758	1024 x 8 (450ns)	2.49
2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	2.95
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	7.90
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	4.45
2732-250	4096 x 8 (250ns) (5v)	8.45
2732-200	4096 x 8 (200ns) (5V)	11.45
2764	8192 x 8 (450ns) (5v)	6.45
2764-250	8192 x 8 (250ns) (5v)	7.45
2764-200	8192 x 1 (200ns) (5v)	16.45
TMS2564	8192 x 8 (450ns) (5v)	14.45
MC68764	8192 x 8 (450ns) (5v) (24 pin)	38.95
27128	16384 x 8 Call	24.45

5v = Single 5 Volt Supply

74LS00

74LS00	.23	74LS173	.68
74LS01	.24	74LS174	.54
74LS02	.24	74LS175	.54
74LS03	.24	74LS181	2.10
74LS04	.23	74LS189	8.90
74LS05	.24	74LS190	.88
74LS08	.27	74LS191	.88
74LS09	.28	74LS192	.78
74LS10	.24	74LS193	.78
74LS11	.34	74LS194	.68
74LS12	.34	74LS195	.68
74LS13	.44	74LS196	.78
74LS14	.58	74LS197	.78
74LS15	.34	74LS221	.88
74LS20	.24	74LS240	.94
74LS21	.28	74LS241	.98
74LS22	.24	74LS242	.98
74LS26	.28	74LS243	.98
74LS27	.28	74LS244	1.25
74LS28	.34	74LS245	1.45
74LS30	.24	74LS247	.74
74LS32	.28	74LS248	.98
74LS33	.54	74LS249	.98
74LS37	.34	74LS251	.58
74LS38	.34	74LS253	.58
74LS40	.24	74LS257	.58
74LS42	.48	74LS258	.58
74LS47	.74	74LS259	2.70
74LS48	.74	74LS260	.58
74LS49	.74	74LS266	.54
74LS51	.24	74LS273	1.45
74LS54	.28	74LS275	3.30
74LS55	.28	74LS279	.48
74LS63	1.20	74LS280	1.95
74LS73	.38	74LS283	.68
74LS74	.34	74LS290	.88
74LS75	.38	74LS293	.88
74LS76	.38	74LS295	.98
74LS78	.48	74LS298	.88
74LS83	.59	74LS299	1.70
74LS85	.68	74LS323	3.45
74LS86	.38	74LS324	1.70
74LS90	.54	74LS352	1.25
74LS91	.88	74LS353	1.25
74LS92	.54	74LS363	1.30
74LS93	.54	74LS364	1.90
74LS95	.74	74LS365	.48
74LS96	.88	74LS366	.48
74LS107	.38	74LS367	.44
74LS109	.38	74LS368	.44
74LS112	.38	74LS373	1.35
74LS113	.38	74LS374	1.35
74LS114	.38	74LS377	1.35
74LS122	.44	74LS378	1.13
74LS123	.78	74LS379	1.30
74LS124	2.85	74LS385	1.85
74LS125	.48	74LS386	.44
74LS126	.48	74LS390	1.15
74LS132	.58	74LS393	1.15
74LS133	.58	74LS395	1.15
74LS136	.38	74LS399	1.45
74LS137	.98	74LS424	2.90
74LS138	.54	74LS447	.36
74LS139	.54	74LS490	1.90
74LS145	1.15	74LS624	3.95
74LS147	2.45	74LS640	2.15
74LS148	1.30	74LS645	2.15
74LS151	.54	74LS668	1.65
74LS153	.54	74LS669	1.85
74LS154	1.85	74LS670	1.45
74LS155	.68	74LS674	9.60
74LS156	.68	74LS682	3.15
74LS157	.64	74LS683	3.15
74LS158	.58	74LS684	3.15
74LS160	.68	74LS685	3.15
74LS161	.64	74LS688	2.35
74LS162	.68	74LS689	3.15
74LS163	.64	74LS783	23.95
74LS164	.68	81LS95	1.45
74LS165	.94	81LS96	1.45
74LS166	1.90	81LS97	1.45
74LS168	1.70	81LS98	1.45
74LS169	1.70	25LS2521	2.75
74LS170	1.45	25LS2569	4.20

7400

7400	.18	7482	.94	74172	5.90
7401	.18	7483	.49	74173	.74
7402	.18	7485	.58	74174	.88
7403	.18	7486	.34	74175	1.75
7404	.18	7489	2.10	74176	.88
7405	.24	7490	.34	74177	.74
7406	.28	7491	.39	74178	1.10
7407	.28	7492	.49	74179	1.70
7408	.23	7493	.34	74180	.74
7409	.18	7494	.64	74181	2.20
7410	.18	7495	.54	74182	.74
7411	.24	7496	.69	74184	1.95
7412	.29	7497	2.70	74185	1.95
7413	.34	74100	1.70	74190	1.10
7414	.48	74107	.29	74191	1.10
7416	.24	74109	.44	74192	.78
7417	.24	74110	.44	74193	.78
7420	.18	74111	.54	74194	.84
7421	.34	74116	1.50	74195	.84
7422	.34	74120	1.15	74196	.78
7423	.28	74121	.28	74197	.74
7425	.28	74122	.44	74198	1.34
7426	.28	74123	.48	74199	1.34
7427	.28	74125	.44	74221	1.34
7428	.44	74126	1.44	74246	1.34
7430	.18	74128	.54	74247	1.24
7432	.28	74132	.44	74248	1.80
7433	.44	74136	.49	74249	1.90
7437	.28	74141	.64	74251	.74
7438	.28	74142	2.90	74259	2.20
7440	.18	74143	2.90	74265	1.30
7442	.48	74145	.59	74273	1.90
7443	.64	74147	1.75	74276	1.20
7444	.68	74148	1.75	74279	.74
7445	.68	74150	1.30	74283	1.95
7446	.68	74151	.54	74284	3.70
7447	.68	74152	.64	74285	3.70
7448	.68	74153	.54	74290	.94
7450	.18	74154	1.20	74293	.74
7451	.22	74155	.74	74298	.84
7453	.22	74156	.64	74351	2.20
7454	.22	74157	.54	74365	.64
7460	.22	74159	1.60	74366	.64
7470	.34	74160	.84	74367	.64
7472	.28	74161	.68	74368	.64
7473	.33	74162	.84	74376	2.15
7474	.32	74163	.68	74390	1.70
7475	.44	74164	.84	74393	1.30
7476	.34	74165	.84	74425	3.10
7480	.58	74166	.95	74426	.84
7481	1.05	74167	2.90	74490	2.50
		74170	1.60		

6500

1 Mhz

6502	4.90
6504	6.90
6505	8.90
6507	9.90
6520	4.30
6522	6.90
6532	9.90
6545	21.50
6551	10.85

2 Mhz

6502A	6.90
6522A	9.90
6532A	10.95
6545A	26.95
6551A	10.95

3 Mhz

6502B	9.90

6800

68000	58.95
6800	3.90
6802	7.90
6808	12.90
6809E	18.95
6809	10.95
6810	2.90
6820	4.30
6821	3.20
6828	13.95
6840	11.95
6843	33.95
6844	24.95
6845	13.95
6847	10.95
6850	3.20
6852	15.70
6860	9.90
6862	10.95
6875	6.90
6880	2.20
6883	21.95
68047	23.95
68488	18.95

1 Mhz

68B00	9.95
68B02	21.25
68B09E	28.95
68B09	28.95
68B10	6.90
68B21	6.90
68B45	18.95
68B50	5.90

74S00

74S00	.31	74S163	1.90
74S02	.34	74S168	3.90
74S03	.34	74S169	3.90
74S04	.34	74S174	.94
74S05	.34	74S175	.94
74S08	.34	74S181	3.90
74S09	.39	74S182	2.90
74S10	.34	74S188	1.90
74S11	.34	74S189	6.90
74S15	.34	74S194	1.44
74S20	.34	74S195	1.44
74S22	.34	74S196	1.44
74S30	.34	74S197	1.44
74S32	.39	74S201	6.90
74S37	.87	74S225	7.90
74S38	.84	74S240	2.15
74S40	.34	74S241	2.15
74S51	.34	74S244	2.15
74S64	.39	74S251	.94
74S65	.39	74S253	.94
74S74	.49	74S257	.94
74S85	1.94	74S258	.94
74S86	.49	74S260	.78
74S212	.49	74S274	19.90
74S113	.49	74S275	19.90
74S114	.54	74S280	1.90
74S124	2.70	74S287	1.85
74S132	1.20	74S288	1.85
74S133	.44	74S289	6.84
74S134	.49	74S301	6.90
74S135	.88	74S373	2.40
74S138	.84	74S374	2.40
74S139	.84	74S381	7.90
74S140	.54	74S387	1.90
74S151	.94	74S412	2.93
74S153	.94	74S471	4.90
74S157	.94	74S472	4.90
74S158	.94	74S474	4.90
74S161	1.90	74S482	15.20
74S162	1.90	74S570	2.90

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8035	5.90	8089	88.95
8039	6.90	8155	6.90
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INS-8073	49.95	8156	6.90
8080	3.90	8185	28.95
8085	5.90	8185-2	38.95
8085A-2	10.95	8741	38.95
8086	28.95	8748	49.95
8087	199.00	8755	23.95
8088	38.95		

8200

8202	23.95
8203	38.95
8205	3.45
8212	1.75
8214	3.80
8216	1.70
8224	2.20
8226	1.75
8228	3.45
8237	18.95
8237-5	20.95
8238	4.45
8243	10.95
8250	16.95
8251	4.45
8253	6.90
8253-5	7.90
8255	4.45
8255-5	5.20
8257	7.90
8257-5	8.90
8259	6.85
8259-5	7.45
8271	75.00
8272	38.95
8275	28.95
8279	8.90
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8282	6.45
8283	6.45
8284	14.95
8286	6.45
8287	6.45
8288	24.00
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8292	16.95

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2.5 MHZ

Z80-CPU	3.90
Z80-CTC	3.95
Z80-DART	10.95
Z80-DMA	13.95
Z80-PIO	3.95
Z80-SIO/0	11.95
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4.0 MHZ

Z80A-CPU	4.29
Z80A-CTC	4.90
Z80A-DART	9.95
Z80A-DMA	12.95
Z80A-PIO	4.29
Z80A-SIO/0	12.95
Z80A-SIO/1	12.95
Z80A-SIO/2	12.95
Z80A-SIO/9	12.95

6.0 MHZ

Z80B-CPU	9.95
Z80B-CTC	12.95
Z80B-PIO	12.95
Z80B-DART	12.95

ZILOG

Z6132	33.9
Z8671	38.9

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8T26	1.54	8T98	.88
68T28	1.84	DM8131	2.90
8T95	.88	DP8304	2.24
8T96	.88	DS8835	1.94
8T97	.88	DS8836	.98

Circle 125 on inquiry card.

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1791	23.95	6843	33.95
1793	25.95	8272	38.95
1795	48.95	UPD765	38.95
1797	48.95	MB8876	28.95
2791	79.95	MB8877	33.95
2793	79.95	1691	16.95
2795	84.95	2143	17.95

CRYSTALS

1.0000 MHz	3.69	8.0000 MHz	2.69
1.8432 MHz	3.69	10.0000 MHz	2.69
2.0000 MHz	2.69	10.7386 MHz	2.69
2.0972 MHz	2.69	12.0000 MHz	2.69
2.4576 MHz	2.69	14.3182 MHz	2.69
3.2768 MHz	2.69	15.0000 MHz	2.69
3.5795 MHz	2.69	16.0000 MHz	2.69
4.0000 MHz	2.69	17.4300 MHz	2.69
4.1943 MHz	2.69	18.0000 MHz	2.69
4.9160 MHz	2.69	18.4320 MHz	2.69
5.0000 MHz	2.69	19.6608 MHz	2.69
5.0688 MHz	2.69	20.0000 MHz	2.69
5.1850 MHz	2.69	22.1184 MHz	2.69
5.2429 MHz	2.69	32.0000 MHz	2.69
5.7143 MHz	2.69	36.0000 MHz	2.69
6.0000 MHz	2.69	48.0000 MHz	2.69
6.1440 MHz	2.69	49.4350 MHz	2.69
6.4000 MHz	2.69	49.8900 MHz	2.69
6.5536 MHz	2.69		

32.768 KHz. 1.69

CRYSTAL CLOCK OSCILLATORS

PART NO.	FREQUENCY	PRICE
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1.843	1.8432 MHz	9.95
2.000	2.0000 MHz	9.95
4.000	4.0000 MHz	9.95
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10.000	10.0000 MHz	9.95
16.000	16.0000 MHz	9.95
18.432	18.4320 MHz	9.95
19.660	19.6608 MHz	9.95
20.000	20.0000 MHz	9.95
32.000	32.0000 MHz	9.95

VOLTAGE REGULATORS

7805T	.74	7905T	.84
78M05C	.34	7908T	.84
7808T	.74	7912T	.84
7812T	.74	7915T	.84
7815T	.74	7924T	.84
7824T	.74	7905K	1.44
7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
7824K	1.34	79L05	.78
78L05	.68	79L12	.78
78L12	.68	79L15	.78
78L15	.68	LM323K	4.90
78H05K	9.90	UA78S40	1.90
78H12K	9.90		

C,T = TO-220 K = TO-3
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4 POSITION	.84
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7 POSITION	.94
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(1 to 99)

8 pin ST	.12	8 pin WW	.58
14 pin ST	.14	14 pin WW	.68
16 pin ST	.16	16 pin WW	.68
18 pin ST	.19	18 pin WW	.98
20 pin ST	.28	20 pin WW	1.04
22 pin ST	.29	22 pin WW	1.34
24 pin ST	.29	24 pin WW	1.44
28 pin ST	.39	28 pin WW	1.64
40 pin ST	.48	40 pin WW	1.94

ST = Soldertail WW = Wirewrap

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- Inverse Video
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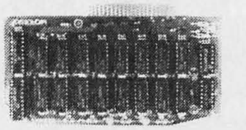
- 64K RAM expandable to 128K

64K RAM Upgrade 43.60



QUV-T8/1 EPROM Eraser

QUV-T8/1 Economy Model: Low cost EPROM eraser in plastic enclosure. The UV element is in the lid and you place the EPROMS in the bottom half. No timer or switch option.

- Erases up to 8 EPROMS in 15 - 20 minutes.
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- 90-Day Warranty **49.95**

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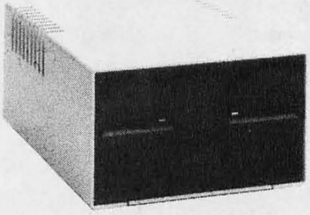
Joystick	29.95
RF Modulator	13.95
Disk Drive	199.00
Controller Card	59.95

APPLE COMPATIBLE DISK DRIVE



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- One Year Warranty

CONTROLLER CARD... 59.95

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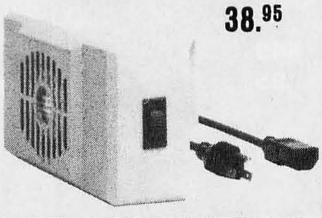

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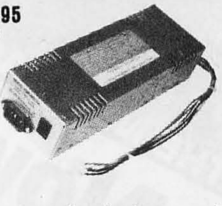
74.95



- Powers Apple type systems
- +5V @ 5A +12V @ 3A
  −5V @ .5A −12V @ .5A
- Includes instructions

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16K RAM Card – Apple II+

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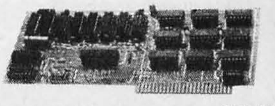

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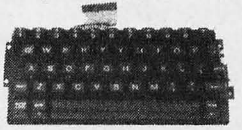

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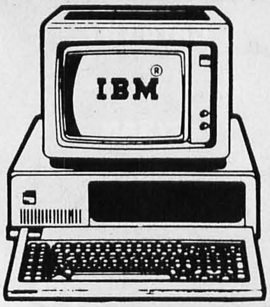

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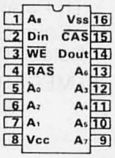

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4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
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4522	1.25	74C926	7.95
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6800

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6800	2.95
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6803	19.95
6808	13.90
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6809	11.95
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6820	4.35
6821	2.95
6828	14.95
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6850	3.25
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6860	7.95
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6880	2.25
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68488	19.95

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68B45	19.95
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68B00 2 MHZ

6500

1 MHZ

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6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	6.95
6532	9.95
6545	22.50
6551	11.85

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6522A	9.95
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6545A	27.95
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3 MHZ

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8216	1.75
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8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	79.95
8272	39.95
8275	29.95
8279	8.95
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8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
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8292	14.95

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Z80-DMA	14.95
Z80-PIO	3.95
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Z80-SIO/1	11.95
Z80-SIO/2	11.95
Z80-SIO/9	11.95

4.0 Mhz

Z80A-CPU	4.49
Z80A-CTC	4.95
Z80A-DART	9.95
Z80A-DMA	12.95
Z80A-PIO	4.49
Z80A-SIO/0	12.95
Z80A-SIO/1	12.95
Z80A-SIO/2	12.95
Z80A-SIO/9	12.95

6.0 Mhz

Z80B-CPU	9.95
Z80B-CTC	12.95
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Z80B-DART	19.95
Z80B-SIO/2	39.95

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74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS375	.95
74LS122	.45	74LS377	1.39
74LS123	.79	74LS378	1.18
74LS124	2.90	74LS379	1.35
74LS125	.49	74LS385	3.90
74LS126	.49	74LS386	.45
74LS132	.59	74LS390	1.19
74LS133	.59	74LS393	1.19
74LS136	.39	74LS395	1.19
74LS137	.99	74LS399	1.49
74LS138	.55	74LS424	2.95
74LS139	.55	74LS447	.95
74LS145	1.20	74LS490	1.95
74LS147	2.49	74LS624	3.99
74LS148	1.35	74LS640	2.20
74LS151	.55	74LS645	2.20
74LS153	.55	74LS668	1.69
74LS154	1.90	74LS669	1.89
74LS155	.69	74LS670	1.49
74LS156	.69	74LS674	14.95
74LS157	.65	74LS682	3.20
74LS158	.59	74LS683	3.20
74LS160	.69	74LS684	3.20
74LS161	.65	74LS685	3.20
74LS162	.69	74LS688	2.40
74LS163	.65	74LS689	3.20
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

74S00

74S00	.32	74S124	2.75	74S197	1.49
74S02	.35	74S132	1.24	74S201	6.95
74S03	.35	74S133	.45	74S225	7.95
74S04	.35	74S134	.50	74S240	2.20
74S05	.35	74S135	.89	74S241	2.20
74S08	.35	74S138	.85	74S244	2.20
74S09	.40	74S139	.85	74S251	.95
74S10	.35	74S140	.55	74S253	.95
74S11	.35	74S151	.95	74S257	.95
74S15	.35	74S153	.95	74S258	.95
74S20	.35	74S157	.95	74S260	.79
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74S30	.35	74S161	1.95	74S280	1.95
74S32	.40	74S162	1.95	74S287	1.90
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74S38	.85	74S168	3.95	74S289	6.89
74S40	.35	74S169	3.95	74S301	6.95
74S51	.35	74S174	.95	74S373	2.45
74S64	.40	74S175	.95	74S374	2.45
74S65	.40	74S181	3.95	74S387	1.95
74S74	.50	74S182	2.95	74S412	2.98
74S85	1.99	74S188	1.95	74S471	4.95
74S86	.50	74S189	6.95	74S472	4.95
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74S114	.55	74S196	1.49	74S571	2.95

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78M05C	.35	7908T	.85
7808T	.75	7912T	.85
7812T	.75	7915T	.85
7815T	.75	7924T	.85
7824T	.75	7905K	1.49
7805K	1.39	7912K	1.49
7812K	1.39	7915K	1.49
7815K	1.39	7924K	1.49
7824K	1.39	79L05	.79
78L05	.69	79L12	.79
78L12	.69	79L15	.79
78L15	.69	LM323K	4.95
78H05K	9.95	UA78S40	1.95
78H12K	9.95		

C, T = TO-220 K = TO-3
L = TO-92

7400

7400	.19	74123	.49
7401	.19	74125	.45
7402	.19	74126	.45
7403	.19	74132	.45
7404	.19	74136	.50
7405	.25	74143	4.95
7406	.29	74145	.60
7407	.29	74147	1.75
7408	.24	74148	1.20
7409	.19	74150	1.35
7410	.19	74151	.55
7411	.25	74153	.55
7413	.35	74154	1.25
7414	.49	74155	.75
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7425	.29	74163	.69
7427	.29	74164	.85
7430	.19	74165	.85
7432	.29	74166	1.00
7437	.19	74167	2.95
7438	.29	74170	1.65
7442	.49	74173	.75
7445	.69	74174	.89
7446	.69	74175	.89
7447	.69	74177	.75
7448	.69	74181	2.25
7451	.23	74184	2.00
7473	.34	74185	2.00
7474	.33	74191	1.15
7475	.45	74192	.79
7476	.35	74193	.79
7482	.95	74194	.85
7483	.50	74195	.85
7485	.59	74197	.75
7486	.35	74198	1.35
7489	2.15	74221	1.35
7490	.35	74246	1.35
7492	.50	74247	1.25
7493	.35	74259	2.25
7495	.55	74273	1.95
7497	2.75	74276	1.25
74100	1.75	74279	.75
74107	.30	74366	.65
74109	.45	74367	.65
74116	1.55	74368	.65
74121	.29	74393	1.35
74122	.45		

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PE-14		9	8,000	83.00
PE-14T	X	9	8,000	119.00
PE-24T	X	12	9,600	175.00
PL-265T	X	30	9,600	255.00
PR-125T	X	25	17,000	349.00
PR-320T	X	42	17,000	595.00

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8T28	1.89
8T95	.89
8T96	.89
8T97	.89
8T98	.89
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DP8304	2.29
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DAC0806	1.95	DAC1020	8.25
ADC0809	4.49	DAC1022	5.95
ADC0816	14.95	MC1408L6	1.95
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XR 2208	3.75
XR 2211	5.25
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ICL7660	2.95
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9000

9316	1.00
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
96S02	1.95

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LM301	.34	LM348	.99	LM567	.89	LM1812	8.25
LM301H	.79	LM350K	4.95	NE570	3.95	LM1830	3.50
LM307	.45	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308	.69	LM358	.69	NE590	2.50	LM1872	5.49
LM308H	1.15	LM359	1.79	NE592	2.75	LM1877	3.25
LM309H	1.95	LM376	3.75	LM709	.59	LM1889	1.95
LM309K	1.25	LM377	1.95	LM710	.75	LM1896	1.75
LM310	1.75	LM378	2.50	LM711	.79	ULN2003	2.49
LM311	.64	LM379	4.50	LM723	.49	LM2877	2.05
LM311H	.89	LM380	.89	LM723H	.55	LM2878	2.25
LM312H	1.75	LM380N-8	1.10	LM733	.98	LM2900	.85
LM317K	3.95	LM381	1.60	LM741	.35	LM2901	1.00
LM317T	1.19	LM382	1.60	LM741N-14	.35	LM2917	2.95
LM318	1.49	LM383	1.95	LM741H	.40	LM3900	.59
LM318H	1.59	LM384	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM386	.89	LM748	.59	LM3909	.98
LM319	1.25	LM387	1.40	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM389	1.35	LM1303	1.95	LM3914	3.95
LM322	1.65	LM390	1.95	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM392	.69	MC1330	1.69	LM3916	3.95
LM324	.59	LM393	1.29	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	1.49
LM340 (see 7800)		LM566	1.49	LM1800	2.37	MPQ2907	1.95

H TO-5 CAN T = TO-220 K = TO-3

RCA

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CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85

CA 3160 1.19

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TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89

75494 .89

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10

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- ⋆ TO-3 PACKAGE **$3.95**

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SPECIALS END 10-31-84

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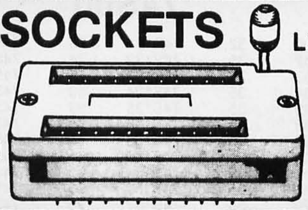

ZIF = Zero Insertion Force

LEADS	UNIT PRICE
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24	7.95
28	8.95
40	10.95

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2N918	.50	MPS3706	.15
MPS918	.25	2N3772	1.85
2N2102	.75	2N3903	.25
2N2218	.50	2N3904	.10
2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
PN3644	.25	TIP29	.65
MPS3704	.15	TIP31	.75
		TIP32	.79

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call

ST = SOLDERTAIL

8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
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4N26	1.00	MCA-7	4.25
4N27	1.10	MCA-255	1.75
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4N33	1.75	ILA-30	1.25
4N35	1.25	ILQ-74	2.75
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	6V	10V	15V	20V	25V	35V
.22uf						.40
.27						.40
.33						.40
.47				.35		.50
.68						.45
1.0			.40	.40	.45	.45
1.5				.45		.50
1.8						.75
2.2		.35	.40	.45		.65
2.7		.40	.45			.90
3.3		.45	.50	.55	.60	.65
3.9			.45			
4.7	.45	.55		.60	.65	.85
6.8			.70		.75	
10	.55	.65	.80	.85	.90	1.00
12	.65		.85	.90		
15	.75	.85	.90			
18			1.25			
22		1.00	1.35			
27			2.25			
39		1.50				
47	1.35					
56	1.75					
100		3.25				
270	3.75					

DISC

10pf	50V	.05	470	50V	.05
22	50V	.05	560	50V	.05
25	50V	.05	680	50V	.05
27	50V	.05	820	50V	.05
33	50V	.05	.001uf	50V	.05
47	50V	.05	.0015	50V	.05
56	50V	.05	.0022	50V	.05
68	50V	.05	.005	50V	.05
82	50V	.05	.01	50V	.07
100	50V	.05	.02	50V	.07
220	50V	.05	.05	50V	.07
330	50V	.05	.1	12V	.10
			.1	50V	.12

MONOLITHIC

.1uf-mono	50V	.18	.47uf-mono	50V	.25
.047uf-mono	50V	.15	.01uf-mono	50V	.14

ELECTROLYTIC

RADIAL			AXIAL		
.47uf	50V	.14	1uf	50V	.14
1	25V	.14	4.7	16V	.14
2.2	35V	.15	10	16V	.14
4.7	50V	.15	10	50V	.16
10	50V	.15	22	16V	.14
47	35V	.18	47	50V	.20
100	16V	.18	100	15V	.20
220	35V	.20	100	35V	.25
470	25V	.30	150	25V	.25
2200	16V	.60	220	25V	.30
			330	16V	.40
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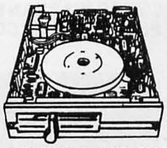
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DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
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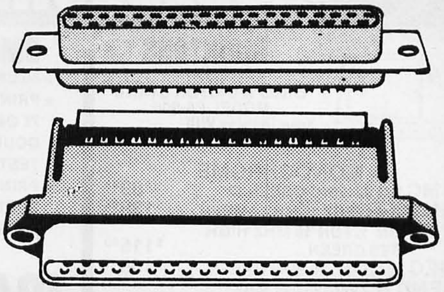
COMPONENT CARRIERS (DIP HEADERS)	ICCxx	.65	.75	.85	1.00	1.25	1.25	1.35	1.50	2.10
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	----	1.45	1.65	----	----	----	2.50	----	4.15

For order instructions see "IDC Connectors" below.

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	25	37	50
SOLDER CUP	MALE	DPxxP	2.08	2.69	2.50	4.80	6.06
	FEMALE	DBxxS	2.66	3.63	3.25	7.11	9.24
RT. ANGLE PC HOLDER	MALE	DBxxPR	1.65	2.20	3.00	4.83	---
	FEMALE	DBxxSR	2.18	3.03	4.42	6.19	---
IDC RIBBON CABLE	MALE	IDBxxP	3.37	4.70	6.23	9.22	---
	FEMALE	IDBxxS	3.69	5.13	6.84	10.08	---
HOODS	BLACK	HOOD-B	---	---	1.25	---	---
	GREY	HOOD	1.60	1.60	1.25	2.95	3.50

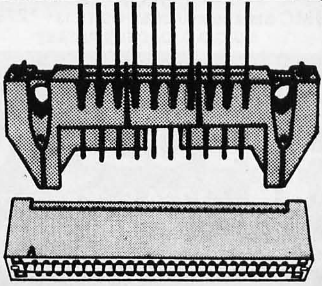
MOUNTING HARDWARE - $1.00 For order instructions see "IDC Connectors" below.



IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RT. ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RT. ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	1.15	1.86	2.43	3.15	3.73	4.65
RIBBON HEADER	IDMxx	----	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	2.25	2.36	2.65	3.25	3.80	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked **"xx"** of the "order by" part number listed. **Example:** A 10 pin right angle holder style header would be IDH10SR.



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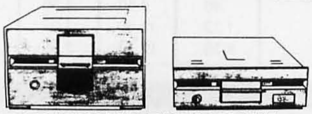

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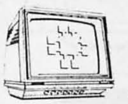

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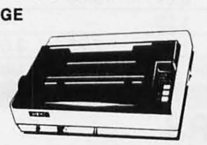

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WANTED: Tax-exempt, nonprofit organization seeks donation of Apple or compatible computer and printer system for legal-assistance project. References and IRS information on request. Will pay reasonable shipping costs. Jeanette Orlando, Women's Legal Clinic, 11544 West Pico Blvd., Los Angeles, CA 90064, (213) 478-0202.

NEEDED: Tax-deductible donation of IBM PC or compatible for a medical-research foundation for word processing, DNA sequence analysis, and statistics sought by molecular biologist returning to South America. Will pay delivery. Dr. M. Leonardo Satz, NCI, NIH, Building 10/4B17, Bethesda, MD 20205, (301) 496-9097.

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WANTED: Nonprofit, charitable organization welcomes fully tax-deductible contributions of TRS-80 computer equipment used in every aspect of its affairs. Dr. Robert Epstein, Cambridge Center for Behavioral Studies, 11 Ware St., Cambridge, MA 02138, (617) 495-9020.

WANTED: A French radio bulletin board video telephone service is looking for cooperation with a North American BBS. We plan to start an "American Corner" in our service and "Coin Français" in America in ASCII 300/300. ARTS, 6 rue des Ormes, 9412 Fontenny-Sous-Bois, France; tel: (01) 877-3232, 876-4534, 873-9235.

WANTED: A handicapped man would appreciate the donation of an Apple IIe, including keyboard, monitor, two disk drives, phone modem, and mouse. Word-processing software and a letter quality printer also welcome. Jim Krauth; 1 West Briar Dr., Madison Heights, VA 24572, (804) 929-3416.

WANTED: IBM PC or compatible. H. H. Suarez, 16 bis, chemin des Genêts, 1202 Geneva, Switzerland.

WANTED: Schematic and technical information for an LA180 DEC Printer I. I can supply information on how to make the LA180 operate with a Centronics interface. Orville Boston, 650 Blue Ridge Rd., Pittsburgh, PA 15239.

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FOR SALE: H-/Z-89 includes 64K RAM, three RS-232C serial ports, one 5¼-inch disk drive. Also, many utilities: asking $800. Eric Mitchell, 43038 Burlwood Dr., Lancaster, CA 93534, (805) 943-1051.

FOR SALE: Nine S-100 boards with documentation. SD-VDB2480 video, SD-Versafloppy FDC, Ithaca Z80 CPU, CCS-2710 serial I/O, CCS-2422 FDC, CCS-2810 CPU, SSM-IO-4 serial/parallel, Jade-DD FDC, DRC 16K RAM. Best offer over $1000 for all. Arthur Zatarain, 269 Hollywood Dr., Metairie, LA 70005, (504) 835-4574 days.

FOR SALE: Godbout 12-slot motherboard. Factory A & T with active termination. Never used; $75. Mullen TB-4 S-100 Extender Board Kit with Logic Probe, new, complete: $37.50. J. M. Moulder, POB 1627, Poughkeepsie, NY 12601.

NEEDED: Full-time freelance writer would like to borrow computer and printer to complete books contracted for by publishers. I have word-processing software for Apple IIe, Franklin, IBM PC, or TRS-80 I/III/4. Can credit benefactor. Will pay shipping both ways. M. Banks, POB 312, Milford, OH 45150.

WANTED: High school student would appreciate a donated IBM or an Apple IIe personal computer for programming and experimental purposes. Will pay postage. Bill Adrian, 5974 Log House Rd. Rt. 2, Hartford, WI 53027.

FOR SALE: Shugart SA 400 DD35T: $75. Four S-100 8K static RAM boards: $30 each. S-100 4-MHz Z-80 board: $50. S-100 2P+2S I/O board kit: $75. ASCII keyboard: $25. All of above for $300, was $1250. Shipped UPS prepaid. David Germain, 2415 North 39th Place, Phoenix, AZ 85008, (602) 275-6620.

FOR SALE: Altos 586-10 16-bit multiuser system with 10-MHz 8086 Z-80, 8089, 10-megabyte hard disk, 1-megabyte floppy, 512K RAM, and a CP/M emulator. System is expandable: $8000. Mickey Franklin, 855 Victor Ave. #302, Inglewood, CA 90302, (213) 671-6934.

FOR SALE: Cromemco Z-80 ZPU board with 18-slot terminated, fully populated S-100 motherboard on rack-mount frame with guides: $399 or offer. Also, S-100 IMSAI 24 by 80 VIO with possible graphics capability (memory mapped): $199. All above with documentation. Will accept offers. A. Tan, 5749 South Nepal Way, Aurora, CO 80015.

FOR SALE: Memory chips: 64K dynamic RAMs for the TI PC. These will plug into the RAM board and work exactly the same as the TI RAMs: $9.50 each. James Cox, 1712 Northcrest Dr., Plano, TX 75075 (214) 422-2968 after 6 p.m.

FOR SALE: Tektronix 4006-1 graphics terminal and 4631 hard-copy unit. Both new in 1979, both in excellent condition. Were $7500 new; asking $1250 each or best offer. Bryan Noe, 2581 River Oak Dr., Decatur, GA 30033, (404) 329-6251.

SEEKING: Worldwide correspondence with computerists. Exchange information, ideas, and news. Interested in languages, education, and graphics. Tariq B. Tahir 58-U Block 6 PECHS, Karachi-29, Pakistan.

WANTED: BYTE back issue—August 1980. I am interested in the articles on the FORTH programming language. L. W. Becker II, 144 East Burk Ave., Wildwood, NJ 08260.

FOR SALE: Pronto Series 16 computer. Runs MS-DOS 2.0 and is IBM PC compatible. 256K RAM, green swivel/tilt, high-resolution monitor. Uses Intel 80186 CPU. 800K floppy drive and Winchester cartridge (five megabytes): $3900. David Klotzbach, 25 Columbia Circle, Plymouth, MA 02360, (617) 747-0430.

FOR SALE: OSI C4P-MF, 36K, disk drive, black-and-white TV monitor: $600. I ship with all documentation and newsletter collection. Also, Novation Cat, Okidata 82: make an offer. Ted Morris, 6306 Kincaid Rd., Cincinnati, OH 45213-1418, (513) 731-3451.

WANTED: The Epson HX-20 Users' Group (HUG) seeks programming and hardware ideas for its newsletter that facilitates the exchange of ideas among HX-20 users. Ad space is available. HUG, 415 Herondo, Box 334, Hermosa Beach, CA 90254.

FOR SALE: Apple II+, 48K late model rev7 with Videx keyboard enhancer, eight function keys, coresident Applesoft/Integer BASIC: $650. 128K RAM card with software: $180. Disk II with controller: $200. Disk II: $160. All for $1100 prepaid. Also, Apple Graphics Tablet: $375. J. Catholos, Box 44032, Omaha, NE 68144, (402) 895-5309.

WANTED: Lowercase board for TRS-80 Model I Level II or word processor capable of handling lowercase without lowercase display. Steve Cohn, 33 Cameo Rd., Commack, NY 11725.

WANTED: Modem and Expander I for Video Brain Computer. James Wright, POB 435, Denton, MD 21629, (301) 479-2000 days or 479-3835 evenings.

WANTED: Integer card, disk drive, and KoalaPad. Michael Susor, 101 Buena Vista E, San Francisco, CA 94117.

FOR SALE: NEC 7720 high-speed impact printer with serial and parallel I/O, bidirectional tractors. Full-function keyboard with numeric keypad. 55 cps, complete graphics capability. With all cables, Apple parallel card, manuals, factory packaging: $2975 postpaid. Craig Bledsoe, S.R. Box 20286, 4.5 Mile Goldstream Rd., Fairbanks, AK 99701, (907) 455-6904.

WANTED: Sanyo computer owners who would like to start or join a users group to explore its capabilities and potential by exchanging information, ideas, advice, and a newsletter. Want to sell VIC-20 with dataset and 8K expander. Timothy Myers, 1301 South Puget Dr. A23, Renton, WA 98055.

FOR SALE: Century Data Systems 833DA 300-megabyte drives (like T302), microperipherals ICOM dual 8-inch floppy drives, AED 6200 LP dual 8-inch drives, Qantex 2200 tape cartridge drive, Teletype Dataspeed 40-line printer, ADDS CRT terminals, TEC terminals, and one old IBM 1052. Keith Lamont, 135 Ann St., Clarendon Hills, IL 60514, (312) 654-1794.

WANTED: Bidirectional tractor-feed system for C. Itoh FP-1500-25P Starwriter printer; used or new. Hans Muessig, Dennett, Muessig, Ryan & Associates, 1807 Stevens Dr., Iowa City, IA 52240.

FOR TRADE: I would like to swap a four-user PDP-11/03 minicomputer system with 64K memory, hard disk, and dual floppies, for an IBM PC/XT or an Apple II/IIe with monitor, printer, and documentation. Michael Mayfield, Rt. 2, Box 743, Newport, WA 99156, (509) 447-5631.

WANTED: Student would like one keyset from any old or nonfunctioning manual or electric typewriter. Steven Hofman, 30 Highland Ave., Feasterville, PA 19047.

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THE NEW BOMB RULES

Starting with the June issue, perennial winners Steve Ciarcia and Jerry Pournelle have graciously offered to forgo any prize money that they win in the BOMB. BYTE staff members have always been ineligible for the prize money. More of our outside authors will now reap the benefits of doing well in this reader poll.

Computing at Chaos Manor had "A Superbusy Month" and Jerry Pournelle is the first-place winner. John Bono, the author of the second-place feature, "Build A Printer Buffer," wins $100. Third in the countdown this month is Ezra Shapiro's preview of the lightweight but high-powered HP-110. Steve Ciarcia's "Trump Card, Part 2: Software" placed fourth in the top five and in fifth place is Sabina H. Saib's feature on "An Ada Language Primer, Part 1," an introduction to the language endorsed by the Department of Defense. Ms. Saib wins $50. Compliments to these authors for their fine work.

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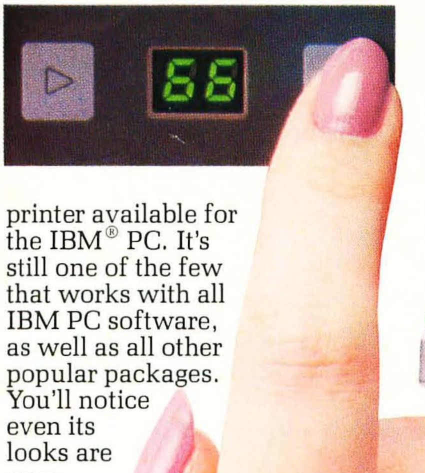

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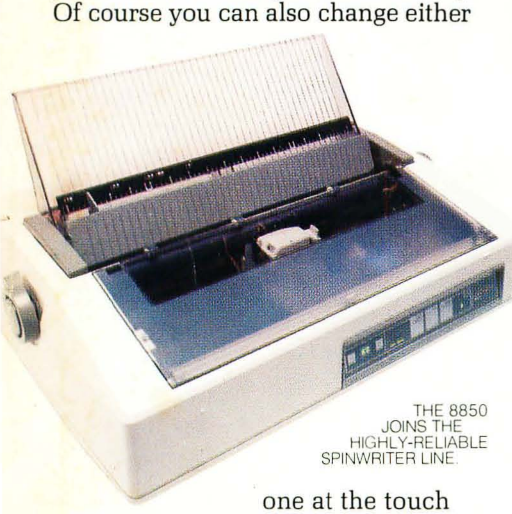

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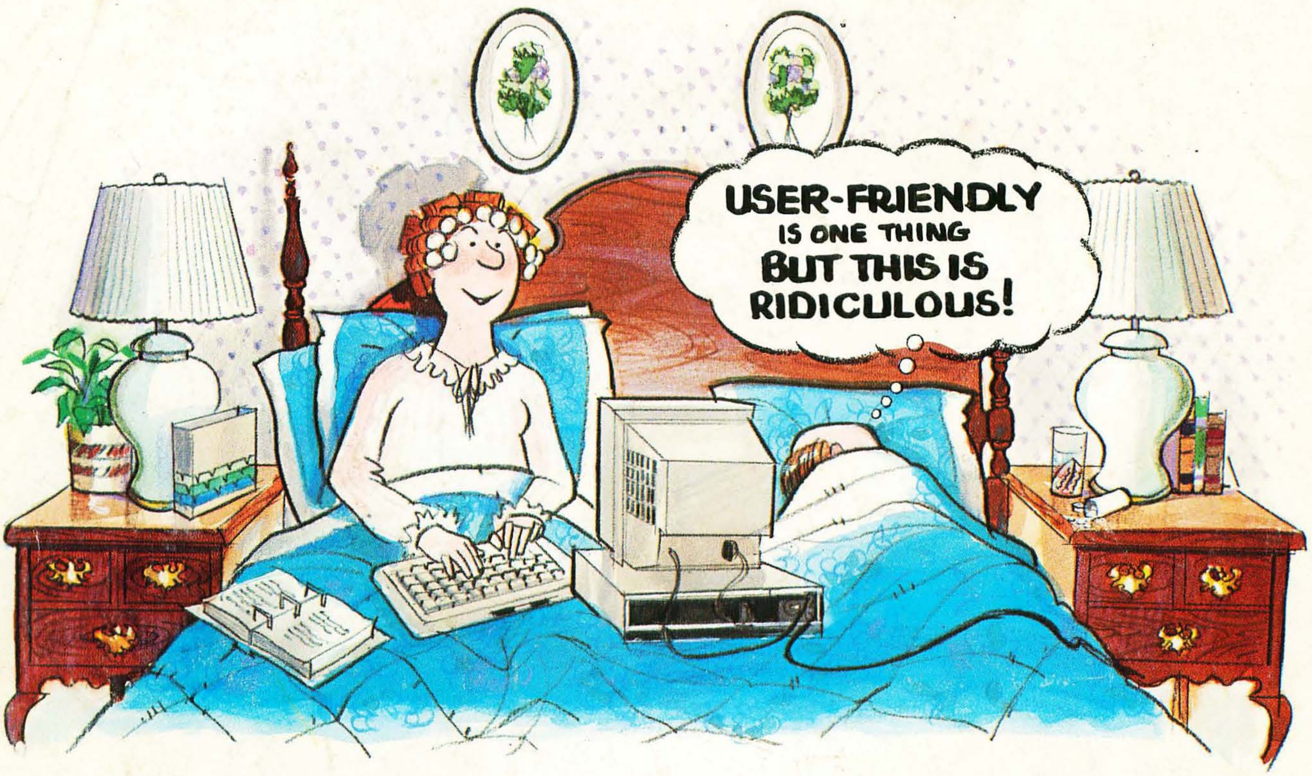

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